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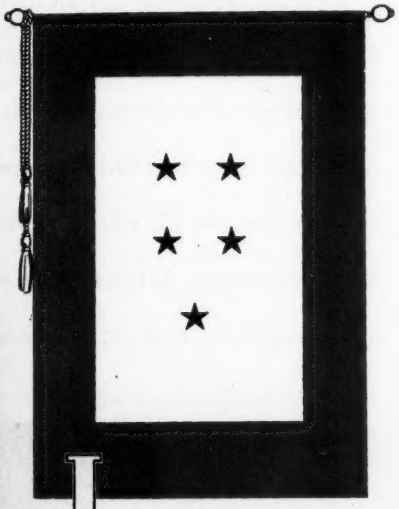

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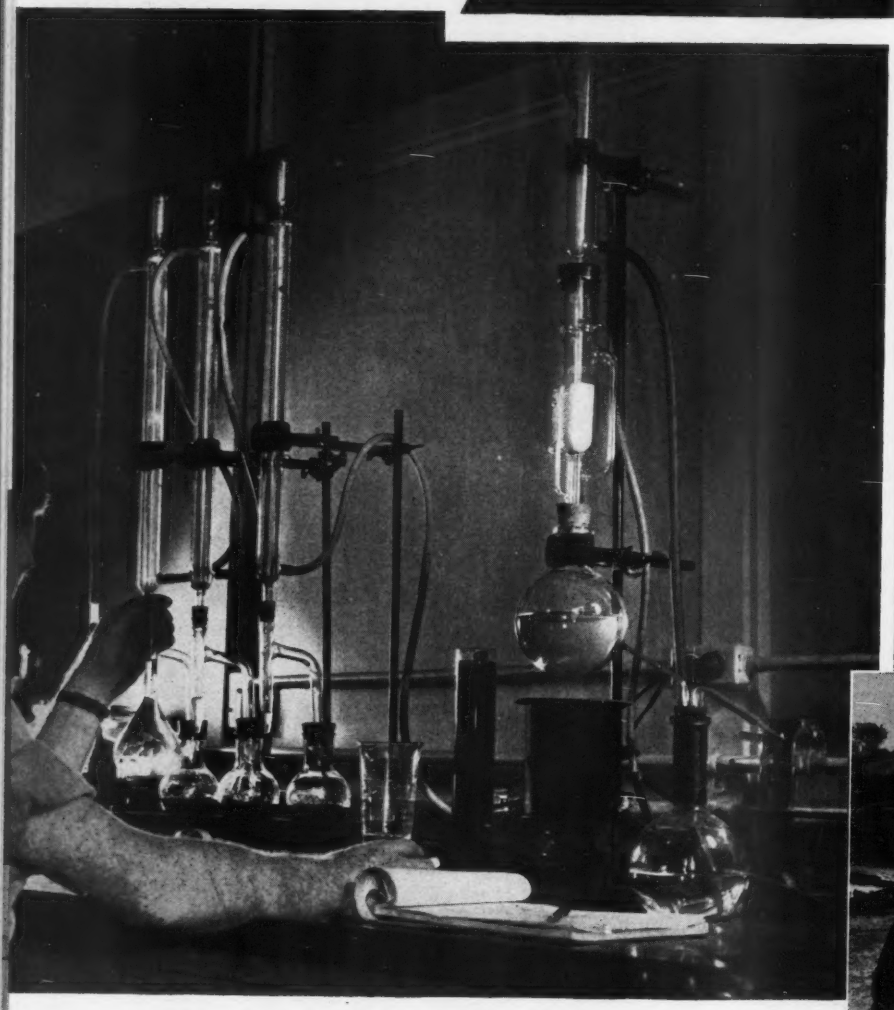

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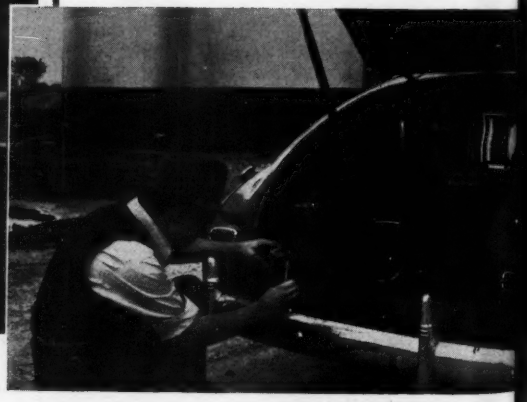

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Administrative Highlights •

H. R. Gallagher Named Director in Charge of District No. 5

Herbert R. Gallagher well known California oil man has been named director in charge for District No. 5 of the Petroleum Administration for War.

Deputy Administrator Ralph K. Davies, in announcing the appointment, said:

"Our District Five office now has directors in charge of the several branches, as Production, Refining, Transportation, Marketing, and Natural Gas and Natural Gasoline. The appointment of Mr. Gallagher as Director in Charge establishes a new general position, better providing for the needed coordination of the various functional divisions and for a senior member who will have over-all responsiblity for the conduct of the affairs of the Petroleum Administration in the western district.

"It is the purpose of the Washington headquarters to follow the principle of decentralization as far as practicable and, to that end, district organizations are being further perfected. The establishment of the new position in District Five is a move in this direction and will, I believe, make possible an improved procedure which will both relieve the Washington office and expedite the handling of West Coast affairs.

"Mr. Gallagher is well known to the industry of the Pacific Coast and will, I know, be regarded as a happy choice."

Mr. Gallagher has had a long and varied experience in the oil industry. He was senior vice president of the Shell Oil Company in California from 1911 to 1932. At the time of the consolidation of the Prairie Oil and Gas Company and the Prairie Pipeline Company with the Sinclair companies in 1932, he went to New York to take the presidency of the combined organization, the Consolidated Oil Corporation. He remained in this position until the fall of 1940, when he retired and returned to live in California. He was chairman of the General Committee of Region One under the NRA; he was a member of the Petroleum War Service Board during the last World War; and has been a director of the American Petroleum Institute since its inception in 1919.

Administrator Briefs Reserves and Discoveries

Petroleum Administrator for War Harold L. Ickes announced on February 4, 1943 that the amount of crude oil discovered in the United States during the year 1942 was only 801,000,000 barrels by the most liberal estimate, or about 57 percent of the approximately 1,400,000,000 barrels actually consumed during the year.

"This estimate," the administrator emphasized, is "a liberal and optimistic estimate of what might be expected on the most favorable probable basis.

"On the basis of the traditional engineering methods of estimating proven reserves of crude oil—under which all calculations are made on the conservative side—only 421,000,000 barrels were discovered during the year."

For the first time, he pointed out, a Federal Government Agency has made a survey of all the new oil fields actually discovered during the calendar year. As a result of this survey, it has been determined that, during 1942, a total of 261 new oil fields were discovered, and 74 new producing horizons were discovered in old fields.

Deputy Administrator Ralph K. Davies said of the report—

"It has been obvious for some time that in the past several years the United States has not been discovering new crude oil reserves in sufficient volume to equal the rate at which we have been taking oil out of the ground to meet the demand. We have been drawing on our accumulated capital to meet our current expenses.

"In ordinary times this would be somewhat serious, but not necessarily alarming, because the trend might soon be reversed. At a time when the nation is engaged in a life or death struggle, it becomes a matter for immediate concern. In order to determine the facts we have had this survey made by the Petroleum Administration for War staff. This is the first time that a Federal Government Agency has ever made a survey to determine the actual amount of new proven oil reserves discovered in any one year."

The results in the leading states were as follows—

	Proven Reserves Discovered 1942	
	Conservative Basis	Possible Maximum Basis
Texas	169,065,000	282,655,000
California	25,625,000	143,460,000
Oklahoma	55,268,000	108,116,000
Louisiana	58,269,000	83,569,000
Kansas	49,084,000	80,389,000
Illinois	22,485,000	28,835,000
All Other States	41,332,000	73,835,000
Total United States	421,128,000	800,859,000

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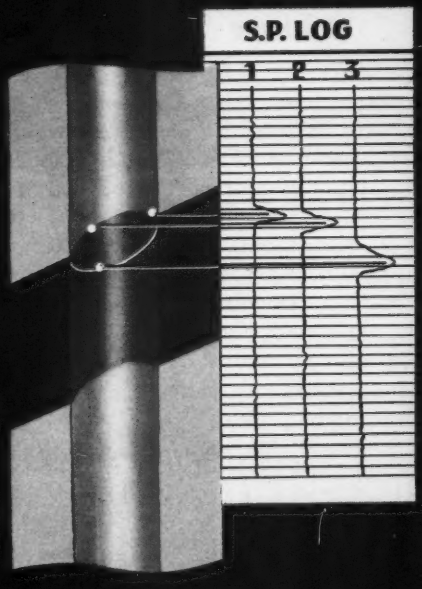

ORIGINATORS OF

Electrical Well Logging

of these figures to the east coast petroleum situation, Mr. Davies pointed out that discoveries in the states of Indiana, Ohio, Kentucky, West Virginia, Pennsylvania and New York accounted for only 1 percent of the total. The state of Michigan accounted for about 1-1/2 percent of the 1942 discoveries. Thus, the only dependable sources of large quantities of oil continued to be in areas far distant from the east coast, involving difficult transportation problems.

As to the effect the curtailment of drilling activity may have had on the discovery of new reserves, the deputy administrator said—

"We recognized early in 1942 that the wartime scarcity of steel would have a serious effect on the number of wells that could be drilled. Therefore, we urged the petroleum industry to stress wildcatting wells drilled in an endeavor to locate new oil fields—, and, within the limits of our powers, drafted all wartime regulations and controls in such a manner as either to encourage wildcatting directly, or at least to minimize the obstacles to such efforts."

Mr. Davies called attention to the figures which showed that although the total number of wells drilled in 1942 decreased 40 percent from 1941, the number of wildcat wells declined only 7 percent. He stated that "this is positive evidence that our measures to encourage wildcatting brought results along the lines we sought."

The number of fields discovered in 1942 per wildcat well drilled when compared to the record in 1941 indicates that it was more difficult to find new oil fields. In 1941, two out of every nineteen wildcats discovered new fields. In 1942 only two out of every twenty-three wildcats discovered new fields. The figures were 342 new fields discovered in 1941 from drilling 3,264 wildcat wells versus 261 new fields discovered in 1942 from drilling 3,045 wildcats.

Petroleum Administrator For War P-98-b Amended— Higher Ratings Assigned

Higher preference ratings for materials required by the oil industry for certain operations were assigned January 30th by the War Production Board under Preference Rating Order P-98-b, which was amended upon the recommendation of the Office of Petroleum Administration for War.

Preference ratings of AA-1 have now been assigned for materials to be delivered to petroleum industry operators for use in maintenance and repair operations or for use in alterations. Previously, these materials were assigned a rating of AA-2X or lower.

The amended P-98-b Order also provides that in cases of actual breakdowns, an operator can expedite delivery of materials by obtaining the counter-signature of the appropriate district office, if the item to be purchased costs less than $500.

In all other instances—including actual breakdowns where an item costs $500 or more—an operator cannot apply an AA-1 rating until he has received approval from the WPB Director General for Operations. Applications for such approval should be addressed to the Petroleum Administration for War, South Interior Building, Washington, D. C., Reference: P-98-b.

Provided that an item costs less than $50 materials to be used in research laboratories may be obtained by applying a rating of AA-2X or lower without a countersignature from a district office or approval from the Washington offices of either PAW or WPB.

The amended order also clarifies the fact than an operator requesting approval to apply various preference ratings no longer is required to name a supplier or suppliers from whom he expects to obtain the material. This means that an operator has greater freedom, once the rating is granted, to purchase his supplies wherever he wishes.

Davies Announces New Appointments

Appointments of David G. Hawthorn, as section chief of the Production Division, and John H. Thacher, Jr., as technical consultant in the Natural Gas and Natural Gasoline Division were announced recently by Deputy Petroleum Administrator Ralph K. Davies.

Mr. Hawthorn is chief of the newly formed Section of Materials and Equipment, which will handle the equipment requirements and allocation for the production branch of the oil industry as affected by the Control Materials Plan.

A resident of Tulsa, Oklahoma, Mr. Hawthorn is on leave of absence from the production department of the Amerada Petroleum Corporation. Born in Cohoes, New York, he moved to Denver, Colorado, during his childhood and attended grammar and high schools in that city. In 1924, he was granted a B. S. in mechanical engineering from the University of Colorado, and four years later was awarded a professional degree of "Degree of Mechanical Engineer."

From 1924 to 1929, Mr. Hawthorn was on the production and production engineering staff of the Marland Oil Company of Oklahoma, with headquarters at Ponca City. In 1929, he transferred to the production engineering department of the Barnsdall Oil Company of Tulsa, where he remained five years. In 1934, he joined the Amerada Corporation, where he remained until July 1942, where he was granted leave to go to the Naval Ordnance Laboratory. He resigned from the Laboratory to go to PAW. Mr. Hawthorn is a member of the American Petroleum Institute and the American Institute of Mechanical Engineers.

Before joining PAW, Mr. Thacher was attached to the Executive Office of the Chairman of the War Production Board, where he served as organizational consultant since June 1942.

A resident of San Francisco, Mr.

(Continued on Page 18)

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A Review of Recent Advances in Drilling-Mud Control

Preston E. Chaney
Sun Oil Co., Beaumont, Texas.

Abstract

A general review of the colloidal chemistry of clays and shales is presented as a theoretical background for the explanation of the various mud problems, and for the chemical treatments used in their correction.

Each of the common mud problems is discussed separately, and an attempt is made to provide a method of diagnosing the cause of trouble from changes in the physical properties of the mud. Following this diagnosis, one or more methods of treatment for correction of the trouble are described, and the theoretical explanation for the action of the corrective treatment is presented whenever possible.

A table showing the combinations of mud properties, or "symptoms" associated with each type of trouble, together with an outline of the corrective treatment, is presented as an aid in rapidly deciding upon the cause of trouble and in selecting the proper treatment.

It is urged that more effort be applied to determination of the cause of mud trouble. A careful study of the results of the various field mud tests is ordinarily sufficient to indicate the impurity producing trouble, and a method of treatment which eliminates this impurity will give better and more economical results than are obtainable by a trial-and-error treatment to improve certain physical properties of the mud.

Introduction

In recent years the technique of mud control has made rapid advances. The research engineers of the oil industry, of the universities, and of the commercial mud and chemical companies have sought and found explanations for many of the peculiarities of mud behavior. Consequently they are able to predict more accurately than before the response of mud to various treatments and, in many cases, to avoid trouble as well as to correct it.

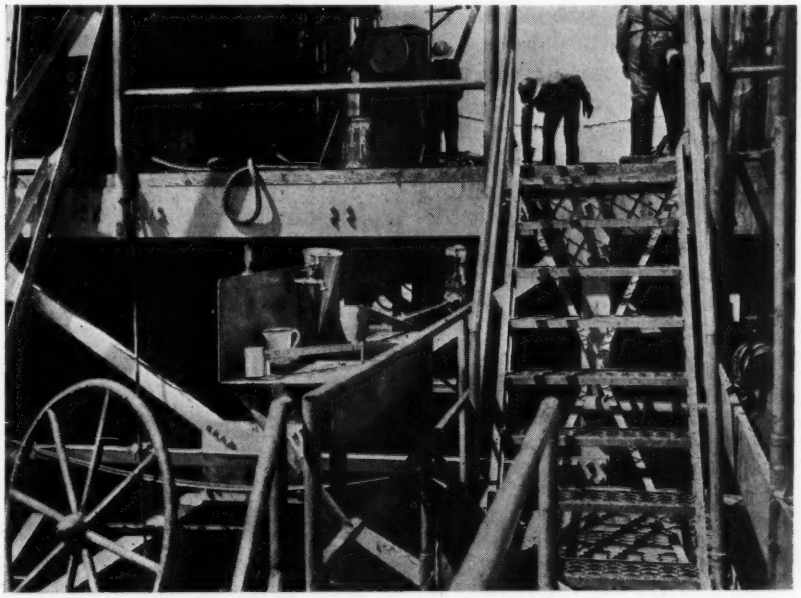
Unfortunately, the field mud engineer often does not have the opportunity to study the literature and to perform the experiments necessary to a practical field application of these new discoveries. Consequently there is a gap between the research departments and field practice which delays the advance in field mud-control technique. To the practical mud engineer, the research man often seems too theoretical, and to the research man, the field engineer seems unwilling to accept new ideas. However, it is necessary to efficient operation that these groups cooperate.

In this paper an attempt is made to bridge this gap between laboratory and field practice. The ordinary mud troubles are considered, and an effort made to explain theoretically both the cause of the trouble and the effects of the corrective chemical treatment. The paper has been written primarily from a practical standpoint, and to the research engineer the theoretical phases probably will appear overly simplified. Most controversial points of theory have been omitted in order to avoid confusion, and only those theoretical explanations which, in the author's opinion, best seem to fit the facts are included. All methods of mud treatment suggested in the following pages have been used successfully and economically in the field.

It is realized in presenting this paper that criticism will come from both research and field engineers, for the reason that a compromise between the two points of view has been attempted. However, if the paper serves to draw these two groups nearer to mutual understanding, and to further the application of fundamental colloid chemistry in the analysis and treatment of field mud problems, it will have served its purpose.

Daily Field Tests on Drilling Mud

The following tests are essential to any proper estimation of mud condition. They should be conducted daily, or more often in case of trouble. A suitable form, or a



This typical deep drilling job in the Valley evidences the care with which mud samples are watched.

More or less permanent drilling operations allow for carefully engineered mud set-ups.

place on the daily drilling report, should be provided for reporting the results of these daily tests:

1. *Weight* (pounds per gallon, pounds per cubic foot, or pounds per square inch per 100 ft. of depth).

   (Note: Hydrometer or balance should be adjusted to the calibration mark with water at least once per day when weight is critical.)
2. *Viscosity* (Marsh-funnel) (in seconds).

   (Note: When commercial weighing materials are used, and in all deep drilling, weight and viscosity should be determined at frequent intervals.)
3. *Sand and total solids* (per cent).

   (One sample from pump suction, and one from flow line.)
4. *pH.*
5. *30-min filter test:*

   a. Record milliliters of filtrate at end of 30 min.

   b. Record cake thickness (32nds of an inch).
6. *Salt*—reported as parts per million of chloride.
7. *Remarks:*

   In the daily report, under "remarks," record any mud properties such as high gel rate, gas bubbles, etc., which may be observed from the general appearance of the mud, which are not indicated directly by the foregoing test results. Also note any tight sections in the hole or other drilling difficulties which might possibly be corrected by suitable adjustments of mud properties.

The American Petroleum Institute has recommended standard methods of conducting the foregoing tests, and detailed procedures may be found in their publication entitled *API Code No. 29: "Recommended Practice on Standard Field Procedure for Testing Drilling Fluids," second edition (1942).*

A Review of Properties of Colloidal Clays and Shales

Inasmuch as such a large proportion of all mud troubles is of chemical origin, it is essential that the field engineer have a working knowledge of the chemistry of colloidal clays. The following discussion of colloidal-clay chemistry is presented only as a review or survey of the literature. For a more complete study of this subject, the reader is referred to the list of references at the end of this paper.

Hydration of Clay Colloids

Colloidal materials may be divided into two general types, according to their action when suspended in water:

The *suspensoids, or hydrophobic colloids,* have little affinity for water and only form a stable suspension if the individual particle charge is sufficiently high to prevent coagulation. Such colloids do not swell in water. The emulsoid or hydrophilic colloids, on the other hand, have a strong affinity for water. Each emulsoid particle "hydrates," or sheaths itself in a protective film of water molecules, and a noticeable swelling of the clay particles results.

The *bentonitic-clay colloids* belong to this latter class, and most of the common mud troubles are caused by undesirable reactions involving these clay colloids. The bentonitic clays and shales are micaceous in structure; i.e., the individual clay particles are thin flat sheets, stacked in mica-like layers. On one of the flat surfaces of these individual leaflets are attached cations, such as Na^+, H^+, Ca^+, etc. The opposite surface, due to internal structure, is slightly negative with respect to the surface bearing these cations. Consequently there is a weak electrostatic attraction between opposite faces of adjacent particles which serves to bind the plates together.

This bonding force is so weak that water molecules may enter and spread the plates apart. This process is responsible for the swelling of the clay, and the "planar water" so attached comprises a large part of the total water retained by the clay colloids.

This planar water is held in place by the weak residual electrostatic forces of the clay particles. These forces increase with increasing ionization of the clay particles; and it is, therefore, to be expected that the degree of swelling and the amount of water retained by the clays should vary according to the particular alkali or alkaline-earth metal present. The relative degrees of ionization of the more common clay salts decrease in the order Li, Na, K, NH_4, Mg, Ca, Sr, Ba, H, according to Jenny and Reitemeier.[1a] Consequently the degree of hydration and the rela-

tive stability of the clays decrease in the same order. This means that, for a given clay concentration, a clay containing sodium ions will swell more in water and will have greater stability in general than a clay in which the sodium is replaced by calcium or magnesium.

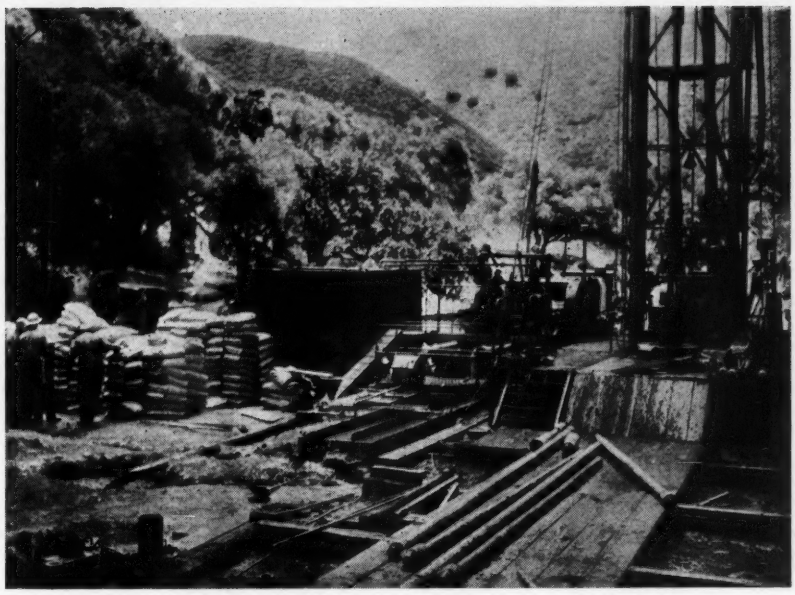
Clays are known by the predominating positive ion as: sodium bentonite, calcium bentonite, etc. The best drilling clays are practically pure sodium bentonites, inasmuch as these clays can retain relatively larger quantities of water and are more stable and more readily dispersed than the alkaline-earth clays, such as calcium bentonite.

Effect of pH Variation on Clay Colloids

The pH of a solution is defined technically as the logarithm of the reciprocal of its hydrogen-ion concentration. In simpler terms, we may consider pure water, which has a pH of 7.0, as neutral. The addition of an alkali, such as sodium hydroxide, increases the pH, whereas the addition of an acid will reduce the pH. As the pH of a solution is reduced, the solution becomes progressively more acid; and, as the pH is increased, it becomes progressively more alkaline.

Variations in the pH, or hydrogen-ion concentration, of a clay suspension produce corresponding changes in the physical properties of the suspension. The pH of a suspension of pure hydrogen bentonite, as obtained by electrodialysis, is in the range 2.0 to 3.0. If sodium hydroxide be added slowly to this suspension, the pH will increase, and the hydrogen ions will be replaced by sodium ions up to a pH between 9.0 to 10.0. At this point the hydrogen ions are replaced completely by sodium, and the clay is now a sodium bentonite rather than a hydrogen bentonite.

Garrison and ten Brink[2] have plotted the course of viscosity and gel-rate variations with increasing pH in bentonite suspensions. They found that in the range of pH 4.5 to about 10.5 the viscosity at low rates of shear decreased with increasing pH, and that a minimum in both viscosity and gel rate occurred in the range of pH 9.5 to 10.5. However, Garrison[3] has shown that the ultimate gel strength of the suspension increases with increasing pH. Thus an increased pH tends to reduce the gel rate, but increases the gel strength; whereas a reduction in pH produces the opposite effect. Hence, to a certain extent, it is possible to adjust the relationship between gel rate and ultimate gel strength by pH control.



Continental Oil Co.'s portable rig in Turnbull Canyon. Operations here require minute attention to mud control.

The mud pH also has an appreciable effect upon the rate of dispersion of shale colloids into the mud system, as has been demonstrated by Garrison, ten Brink, and Elkin.[4] Under the influence of fluid motion the rate of dispersion of shales into the mud stream increases with increasing pH. Therefore, it is possible to increase the yield of natural mud from the shales drilled by maintaining the mud pH in the range of 9.5 to 10.5, rather than in the more usual range of 8.0 to 9.0. On the other hand, when heavily weighted muds are used and trouble is encountered from the rapid accumulation of colloidal material in the mud, it is advisable to reduce the pH to a value between 7.5 and 8.0 in order to retard the rate of shale dispersion.

Also, this treatment is advisable when bentonitic heaving shales are encountered, as a low pH reduces the tendency of these shales to swell and heave into the hole. However, low pH values tend to reduce the gel strength of muds below satisfactory limits, and this fact should be kept in mind whenever pH reduction is contemplated.

Viscosity Relationships of Clay Suspensions

There are at least three factors entering into the viscosity-concentration relationship for any given clay suspensions; these are: 1, the mutual repulsion due to particle charge; 2, the degree of hydration of the colloid particles; and, 3, the mutual attraction due to unsatisfied or partly satisfied broken-bond valences.

1. Repulsion Forces Between Clay Particles

The bentonitic clays may be considered as salts having a normal positive ion, such as sodium or calcium, but having an extremely large negative ion, consisting of the remainder of the clay particle. These "Salts" are ionized to give a positive (sodium, calcium, etc.) ion, and a negative "bentonite" ion. The degree of ionization and, therefore,

[a]Figures refer to REFERENCES.

the effective negative charge on the bentonite particle, depend on the positive ion with which the particle is combined. Thus a sodium bentonite will have a relatively higher negative particle charge than a calcium bentonite because of its higher degree of ionization. This negative particle charge causes a mutual repulsion between the particles, and tends to reduce particle friction and to prevent the formation of aggregates such as are formed when a drilling mud is flocculated by cement. This effect alone would tend to yield lower viscosities in sodium-bentonite suspensions than in calcium-bentonite suspensions of the same concentration, but the expected reduction in viscosity due to greater repulsive forces in the sodium-bentonite suspension is more than balanced by the increase in viscosity due to the higher degree of hydration.

2. Hydration of Clay Particles

The greater degree of ionization and the greater positive-ion hydration of sodium bentonites cause these clays to swell more and to absorb higher percentages of water than the corresponding calcium bentonites. The absorption of water by the clay particles increases their effective diameter, and at the same time inactivates a portion of the water in which the clay is suspended. Both of these effects tend to increase the viscosity of the clay suspension, and are responsible for the fact that higher viscosities are obtained with a given clay concentration using sodium bentonites than with calcium bentonites.

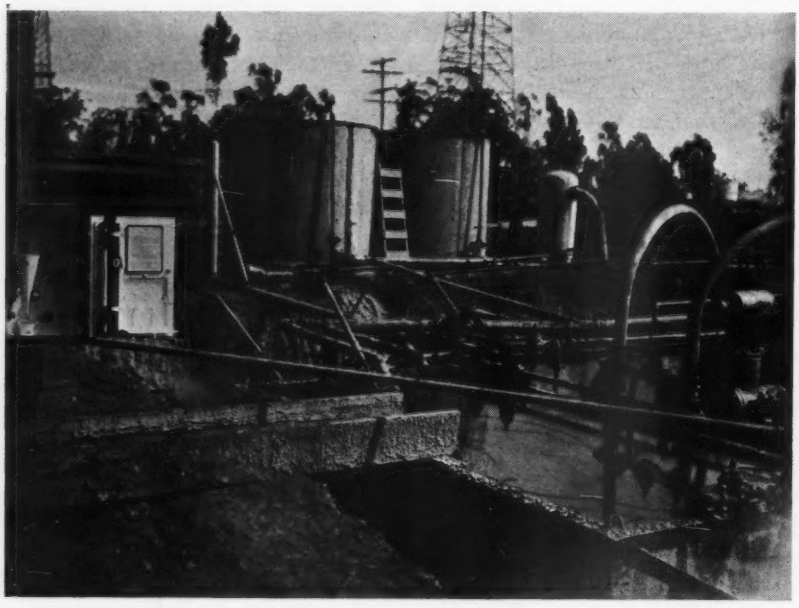
The stability of colloidal suspensions is due to hydration and to the repulsive forces between the individual colloid particles. Any added impurity which tends to reduce the degree of hydration or the particle charge will reduce the stability of the suspension. Thus, when a salt-water flow occurs, the high salt concentration in the drilling fluid serves to dehydrate the clay colloids and to repress their ionization. This reduces the forces stabilizing the suspension and causes flocculation and settling of the clay colloids.

3. Attractive Forces Between Clay Particles

The third factor influencing the viscosity of clay suspensions is that of mutual attraction due to unsatisfied broken-bond valences. As previously explained, the individual clay particles are thin flat sheets, which theoretically could have an unlimited width and length. However, in all natural clays these sheets are broken into sections of very minute width and length. At the surface of this fracture, there are frequently residual valence bonds which originally served to hold the larger sheets together, but which now are left chemically unsatisfied. These residual valences are satisfied in part by the absorption of water at the broken surface, but there remains a relatively strong attractive force tending to pull another clay particle into a position such that it will form a continuation of the clay sheet and completely satisfy the residual valences of both clay particles. This attractive force between the particles tends to increase the friction between them, and thus increases the viscosity of the clay suspension. Furthermore, when the clay suspension is allowed to remain quiescent for a short time, the particles tend to arrange themselves in a definite pattern and to resist any force tending to destroy this pattern. This latter effect is responsible for gelation, and will be discussed more fully in a subsequent paragraph.

Action of Viscosity-Reducing Chemical on Clay Colloids

The primary effect of viscosity-reducing chemical is believed to be a neutralization of these residual broken-bond valences. By the absorption of certain negative ions at the broken-bond surface, these residual valences are satisfied almost completely. Among those negative ions preferentially absorbed at the broken-bond surfaces are the tannates, gallates, and the complex phosphate ions, such as hexametaphosphate, pyrophosphate, and tetraphosphate. The adsorption of these ions at the broken-bond surface alters the balance of forces acting between the clay particles from a preponderantly attractive force, due to these residual valences, to a preponderantly repulsive force, due to the normally weaker negative particle charge produced by ionization. As the forces acting between the particles are now preponderantly repulsive, the particles tend to avoid contact with one another. Particle friction, and the tendency to form gel structures, thus



This drilling rig sump is typical of Basin operations where proper mud control is an important consideration.

are reduced, with a consequent reduction in the viscosity of the clay suspension, or drilling mud.

Gelation of Clay Suspensions

The gelling qualities of a clay suspension are dependent upon the relative attractive and repulsive forces between the clay particles. If the attractive forces due to residual valency are strong and the repulsive forces due to ionization are weak, the mud will have a high gel rate and gel strength. On the other hand, if the repulsive forces are strong, while the attractive forces are weak, the mud will have a slow gel rate and a weak ultimate gel strength.

Any change which tends to alter the relationship between these attractive and repulsive forces will have a pronounced effect upon the gel characteristics of the mud. The addition of small quantities of soluble calcium salts or relatively larger quantities of sodium salts reduces the degree of ionization and, therefore, the negative charge on the clay particles, without materially changing the attractive forces. Consequently the gel rate and gel strength of the mud will be increased. On the other hand, the addition of a complex phosphate, for example, will neutralize the residual broken-bond valences without appreciably reducing the ionization of the clay. Hence the attractive forces are reduced in proportion to the repulsive forces, and a reduced gel rate, gel strength, and viscosity result. In some cases it is difficult to control viscosity by chemical treatment without undesirable reduction in gel strength. Loomis, Ford, and Fidiam[s] have suggested that under such conditions sodium chloride be added to the mud. The addition of moderate amounts of salt (sodium chloride) reduces the repelling forces between the clay particles, by repressing the ionization, and tends to increase the gel strength. However, this treatment has not been used in the field by the author.

A careful study of the theoretical explanations of mud behavior is helpful to an understanding of the "why" of various mud-treatment methods, and assists in a determination of the proper procedure in handling unusual mud problems.

Common Mud Troubles and Chemical Treatment for Their Correction

The author's experience indicates that, in general, each mud trouble produces certain definite changes in the mud properties that are characteristic of that particular trouble. Therefore, it is usually possible to "diagnose" the cause of any given mud trouble from a careful study of changes in the various mud properties produced by it. In this connection it is important to note that changes in the mud properties, rather than their actual values, are used in this diagnosis. The actual values obtained at any one time from the usual mud tests are important to the drilling operation, but often are not sufficient to enable the engineer to diagnose properly the cause of mud troubles. For example, it is possible to produce a very satisfactory mud having a chloride concentration as high as 5,000 ppm.* However, if we start with a mud having a chloride concentration of 1,000 ppm and suddenly increase the concentration to 5,000 ppm, the water loss, gel rate, gel strength, and viscosity will increase beyond satisfactory limits, and the treatment described in following paragraphs for high salt concentrations will be necessary in order to recondition the mud.

In the following paragraphs an effort is made to outline the changes in mud properties characteristic of the various troubles, and to explain the chemical treatments used for their correction after the proper "diagnosis" has been made.

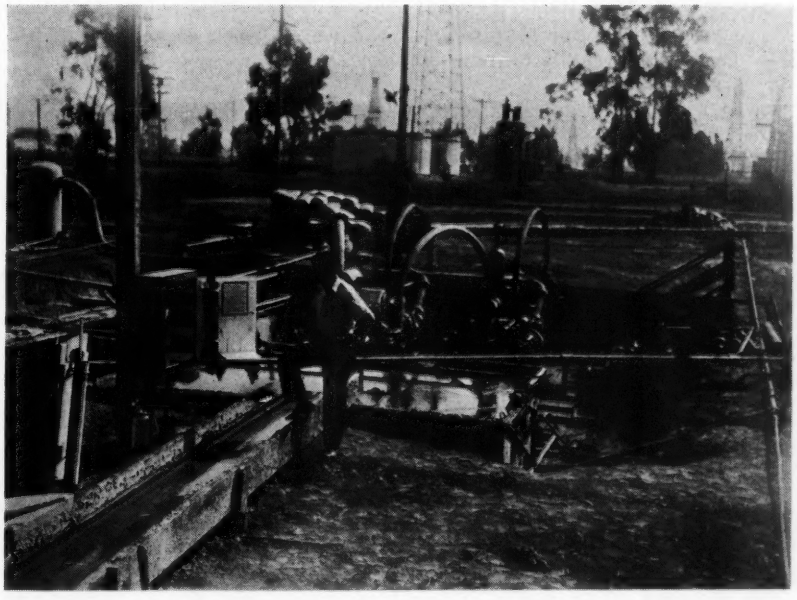
Cement Contamination

One of the most common mud troubles is cement contamination. Usually no "symptoms" are required to locate this trouble, because it may be expected whenever operations require that cement be drilled, and particularly when the cement has not set thoroughly.

Effect of Cement on Clay Colloids

Calcium hydroxide (slaked lime) is present in cement slurries, largely as a result of the hydrolysis of various alkaline calcium silicates and aluminates. The calcium hydroxide so formed is responsible for the observed changes in the mud properties. The calcium ion replaces the sodium on the clay particles, thus

* Parts per million.



No doubts will exist concerning mud control on this well for full facilities have been provided for proper inspection.

converting them to calcium bentonite, while the hydroxyl ion produces a sharp increase in the mud pH. As discussed previously, the calcium clays are not so highly ionized as the sodium clays. Consequently the degree of hydration and dispersion of the clay colloids is reduced. This accounts for the increase in water loss resulting from cement contamination. A further effect of the calcium ion is a flocculation of the clay colloids; i. e., the colloid particles are caused to combine into aggregates of much larger size. Flocculation is responsible for the high viscosity and gel rate of cement-cut muds. The increase in pH, due to the hydroxyl ion coming from the slaked lime, tends to increase further the gel strength of the mud, and thus adds to the trouble.

Corrective Chemical Treatment for Cement Contamination

In treating a cement-contaminated mud we must accomplish the following results:

1. Remove the calcium ions as an insoluble precipitate.
2. Reduce the pH to approximately the value before contamination.
3. Redisperse the clay aggregates as much as possible.
4. Replace with fresh clay any collodial material that cannot be restored readily to its original condition.

In practical application, the first three of these aims are accomplished simultaneously, whereas the fourth is not usually begun until the pH has been reduced to its proper value.

The first treatment consists of a mixture, in about equal proportion, of monosodium, orthophosphate and one of the complex phosphates, or of sodium acid pyrophosphate used alone. The complex phosphate acts as a dispersing agent to break up the clay aggregates, whereas the monosodium phosphate removes the calcium and reduces the pH according to the following chemical reactions:

The first of these reactions is complete before the second begins. It will be observed that sodium hydroxide (caustic soda) is a product of the first reaction and, as this compound is a strong alkali, the pH will not be reduced materially until this reaction has been completed and the second begins. Therefore, by watching for a sharp change in the pH we can tell when all calcium has been precipitated. At this stage in the treatment, the mud usually has a satisfactory Marsh-funnel viscosity —although the viscosity is sometimes even lower than desired, but the rapid gel rate makes the mud appear to have a much higher viscosity, and the high water loss remains unchanged. Addition of fresh bentonite may be begun at this stage if the water loss is exceptionally high, but usually it is better to reduce the pH to its original value by continued use of monosodium phosphate (with only enough complex phosphate to maintain desired viscosity) before clay is added. When the pH has been restored to its original value, the use of monosodium phosphate is discontinued; and, as the final step in the treatment, the ordinary viscosity-controlling agents are used to maintain satisfactory viscosity while the bentonitic clay is being added to reduce the water loss and gel rate of the mud to the desired values.

Pretreatment for Cement Contamination

When it is known in advance that cement contamination will take place, it is advisable to pretreat the mud with as much monosodium phosphate or sodium acid pyrophosphate as can be added without reducing the pH too low or otherwise damaging the mud. This pretreatment will reduce mud flocculation greatly during cement drilling by precipitating most of the undesirable constituents of the cement before serious damage to the mud has occurred.

Lime, Gypsum, Anhydrite, Etc.

As mentioned in the section on cement contamination, any soluble calcium salt will cause the flocculation of colloidal clays. In normal drilling, sections of lime or limey shale, anhydrite, gypsum, etc., are encountered. These calcium salts are sufficiently soluble to cause trouble from clay flocculation.

Effect of Calcium Salts on Clay Colloids

The characteristics of a mud containing soluble calcium salts depends somewhat on the past history of the mud. One of the peculiarities of clay colloids is the effect of calcium salts on the viscosity. If a soluble calcium salt—for example, calcium chloride—is added to a dry sodium bentonite and the clay then is dispersed in water, the viscosity will be very low for a given clay concentration. On the other hand, if the clay first is dispersed in water and allowed to hydrate, the addition of a calcium salt then will produce a sharp increase in the mud viscosity.

In the first case the clay is converted to a calcium clay before it has had time to hydrate, and the calcium clay does not hydrate so completely as would the sodium clay. Therefore, the clay particles have a smaller effective diameter, and higher clay concentrations would be required to cause the same degree of particle interference in the suspension. On the other hand, if the clay first is hydrated, the individual particles have a large diameter due to the swelling produced by hydration. The addition of calcium then flocculates or coagulates these larger particles, causing them to be attracted by one another. This increases the particle friction, with a consequent increase in viscosity.

Effect of Calcium Salts on Field Drilling Muds

In drilling a large shale section containing only moderate amounts of calcium and magnesium salts, the mud will be converted gradually to a calcium-bentonite mud as the original clay is deposited as a filter cake on the walls of the bore hole

and is replaced by these calcium or magnesium clays. This will result in a decreased mud viscosity, a fast gel rate, and usually a slight increase in the water loss.

However, when large sections of anhydrite or gypsum suddenly are encountered—as, for example, in drilling the cap material on many shallow salt domes—a high concentration of cacium is built up rapidly in the mud. This causes flocculation on the sodium clay present in the mud, and results in an increase of gel rate, viscosity, and water loss. It will be noted that, with the exception of the pH, these are the effects produced by cement contamination; and, as the calcium ion is responsible in both cases, we would expect this similarity in effect.

The first set of "symptoms" of calcium contamination ordinarily is encountered only in shallow drilling, with natural muds containing little or no phosphate. In this case, a limey shale section will be found to produce very little mud. The mud produced will have a fast gel rate and a weak gel strength which prevent the proper settling of sand; the viscosity will be abnormally low; and the water loss usually is moderately high. Furthermore, the presence of excess free calcium in the mud will convert to a calcium bentonite any fresh dry clay added to the mud before the clay has had time to hydrate—which would make it necessary to add excessive quantities of clay to obtain the desired increase in viscosity and reduction in water loss and gel rate.

The second set of "symptoms" will be found on any mud when large sections of soluble calcium salts are drilled, and to some degree in drilling limey shale sections with muds containing high concentrations of good clay (low water-loss muds).

Corrective Chemical Treatment for Contamintion by Soluble Calcium Salts

The primary aim of treatment is to precipitate the calcium as an insoluble compound; this may be accomplished by use of disodium phosphate or soda ash, according to the following reactions:

(1) $CaSO_4 + Na_2HPO_4 \longrightarrow \underset{\text{Insoluble}}{CaHPO_4 \downarrow} + Na_2SO_4$

(2) $CaSO_4 + Na_2CO_3 \longrightarrow \underset{\text{Insoluble}}{CaCO_3 \downarrow} + Na_2SO_4$

The choice between these two treating agents is based on the pH of the mud prior to treatment. Disodium phosphate produces little or no change in the mud pH, whereas soda ash increases it sharply. Therefore, disodium phosphate should be used if the mud pH is satisfactory, and soda ash is the correct choice if an increase in pH is desired; monosodium phosphate may be used occasionally if the initial pH of the mud is high.

In this connection, it is advisable to review the foregoing discussion of pH. Usually, in drilling limey shale sections with natural mud, little or no mud is formed from the shale. In order to make more mud from the formation, it is desirable to have the pH in the range 9.5 to 10.0. Therefore, in this case soda ash would be the proper selection.

One of the usual viscosity-reducing chemicals must be used along with the soda ash or disodium phosphate in order to maintain a satisfactory viscosity and to disperse the clay colloids, as these chemicals are not effective in viscosity control.

Particularly in the case of natural muds composed largely of calcium shales it will be found that little change in the mud properties is noticeable until the removal of calcium is practically complete. The viscosity will remain low, and the mud will show a fast gel rate and a weak gel strength, up to the time that sufficient soda ash or disodium phosphate has been added to remove the calcium completely. Sometimes this is discouraging, because treatment may be continued for three or four complete circulations of the mud without any noticeable improvement; however, continued use of the calcium-precipitating agent will give the desired results.

An effort now is being made to develop a satisfactory field test for estimating the calcium concentration in drilling muds. The results of this work, if successful, will be published in the near future.

Gas Cutting

Gas cutting is largely a mechanical, rather than a chemical, problem in mud control. The hydrostatic head of the mud column must be slightly greater than the formation pressure at every point in the hole in order to prevent the flow of formation fluid into the mud system. Gas in the mud indicates that the hydrostatic head of the mud is too low to meet this requirement, and the obvious solution is to increase the mud weight by the addition of commercial weighting materials, such as barytes (barium sulfate).

The addition of weighting material should be begun at the first indication of gas cutting. In this early stage the gas bubbles are very small, and do not rise to the surface of the mud. They are seen best by raking the surface of the mud sample and observing closely for bubbles slightly larger than the point of a pin on the freshly exposed mud surface. This simple test should be performed at frequent intervals when the probability of unusual gas pressures exists; and, if the presence of these small bubbles continues for any length of time, the mud weight should be increased until they disappear.

Corrective Treatment for Gas-cut Muds

In combating high gas pressures, the viscosity and gel rate of the mud should be kept low by chemical treatment to allow the gas bubbles to break out of the mud, and the fluid should be run over a shale shaker or baffle arrangement to allow escape of the entrained gas. Furthermore, the mud pits should be stirred by mud guns to remove any gas not removed at the shale shaker, in order to prevent recycling of the entrained gas. Modern equipment makes it possible to shut the well in and discharge the mud through a choke, if necessary; but

this choke should be used only if the mud is leaving the well faster than the pumps can handle it. The use of a choke puts back pressure on the pumps, and reduces the rate of circulation. This concentrates the gas in a smaller volume of mud, and tends to aggravate the condition.

If weighting material is used, it is advisable to mark the mud level in the pit and observe at frequent intervals for any change. The increase in hydrostatic pressure may cause loss of mud to low-pressure formations; if this occurs before the weight is sufficiently high to hold the gas pressure, suitable measures as discussed under "lost returns" must be taken.

Salt Contamination

Occasionally high-pressure salt water or rock salt is encountered in drilling. As the salt concentration rises in the mud, the high concentration of sodium ions represses the ionization of the clays by simple mass action. This destroys the negative charge on the clay particles, and allows the attractive forces to draw these particles together in large aggregates. The first effect is an increase in gel rate, viscosity, and water loss of the mud. Later, as flocculation and dehydration of the colloids continue, the viscosity falls below normal, and the water loss rises in rough proportion to the salt concentration.

Corrective Treatment for Salt Contamination

The chloride test gives a direct diagnosis" of salt contamination, but the treatment unfortunately is not so easy. In the case of a salt-water flow, the first step in treatment is to increase the mud weight to the point required to stop the flow. This should be done quickly in order to hold the salt concentration in the mud as low as possible. In drilling rock salt, weighting material is, of course, useless in preventing the salt from rapidly building up to the saturation point in the mud, and on the Gulf Coast it is usually necessary to case off any exposed shale sections if more than a few feet of salt must be drilled.

If the salt concentration in the mud can be held below 7,500 ppm of chlorides, the use of disodium phosphate or soda ash to precipitate soluble calcium salts present in the salt water is usually helpful in reducing the gel rate of the mud. However, this treatment has little effect at higher salt concentrations.

The addition of large quantities of Quebracho— sometimes as much as 0.5 to 1.0 lb. per bbl. of mud—also is recommended for reducing the high gel rate produced by high salt concentrations, and in this case the Quebracho may be mixed (about 100 lbs. per hour) through the hopper in order to reach the required concentration in the mud system as rapidly as possible.

The ability of colloidal clays to withstand the flocculating effect of salt water increases with increasing clay concentration. Therefore, it is desirable to add large quantities of a highly colloidal clay, preferably hydrated in fresh water before addition to the mud. When high salt concentrations are present, there is little danger of adding too much clay, as the salt dehydrates the clays and prevents the rise in viscosity that would result from the addition of corresponding amounts of clay to a fresh-water mud.

Use of Organic Colloids in Salt-Water Muds

Recently much research has been conducted in an effort to find a substitute for the clay colloids in salt-water muds. Various organic colloids such as starch, sodium alginate, and various water-soluble natural gums have been tried. These colloids are more resistant to salt flocculation, but all are subject to bacterial attack, which reduces their effectiveness and produces objectionable odors in the mud. However, preservatives such as phenol, formaldehyde, creosote, etc., have been used recently with these materials in both field and laboratory tests, with very promising results.

As is evident from this discussion, salt contamination is at present the most difficult of all mud problems. The usual mud thinners are practically useless, and a mud that will "get by" is frequently the best obtainable with present methods of treatment. However, it is believed that organic colloids will offer a satisfactory solution to this problem as additional field experience in their use and control is made available to the industry.

Heaving Shale

There are at least three known types of heaving shale and any number of combinations of these types. They are classified as follows:

1. Shale that swells on absorption of the fluid phase of the drilling mud—usually a highly bentonitic shale.
2. Shales containing small lenticular sands or sandy shales charged with gas at high pressure but low volume.
3. Shale that has been compressed and uplifted to an angle greater than normal dip, and under considerable diastrophic strain.

Control of Swelling or Bentonitic Heaving Shale

The bentonitic heaving shales contain clay colloids of the type used in drilling muds. Therefore, any chemical treatment designed to prevent the swelling of these shales is likely to be detrimental to the mud. The presence of bentonitic shale is evidenced by a sharp increase in viscosity and, usually, an appreciable reduction in water loss of the drilling mud. In some cases it is possible to control bentonitic shale by reducing the water loss of the mud to the lowest possible value (less than 6.0 ml.) and by the addition of sodium acid pyrophosphate, monosodium phosphate, or some other acidic salt to reduce the mud pH to 7.2 to 7.6. As previously mentioned, the dispersion of clay colloids is delayed by low pH values.

If this treatment is not successful in preventing rapid swelling of the

shale, a mud containing sodium silicate and saturated salt solution as the fluid phase may be substituted for the normal water-base drilling fluid. The sodium silicate "pickles" the shale, and prevents its swelling or dispersing into the mud stream. Excellent results have been obtained by the use of sodium-silicate muds in several areas where drilling was difficult or impossible with water-base muds.

Control of Gas-bearing Heaving Shale

Shales containing small lenticular sands or sandy shales charged with high-pressure gas are apt to heave unless the hydrostatic head of the mud column is sufficient to balance the gas pressure. This type of shale usually gives the mud a fluffy appearance and a sour-gas odor, but does not change appreciably any of the other mud properties. Tight places in the hole are often the first definite proof of its presence.

The first step in treating to prevent heaving in this type of shale is to increase the mud weight to the point required to exceed the gas pressure in the sandy lenses. This is not always possible, because the gas pressure may be high enough to cause loss of mud to other exposed formations of lower pressure before the hydrostatic head of the mud is sufficiently high to balance the gas pressure. In this event, the mud weight should be maintained at the highest value possible without serious loss of mud.

The mud viscosity and gel strength should be kept low to prevent swabbing shale into the hole as the drill pipe is removed, and in some cases equipment has been used to permit continuous circulation while coming out of the hole, in order completely to eliminate swabbing action.

Drilling under pressure has been tried in a few cases to combat this type of shale, but the expense and mechanical difficulties involved in pressure drilling with equipment now available usually make it uneconomical to drill and produce oil zones requiring this type of drilling equipment.

Control of Plastic-Flow Type of Heaving Shale

Shale beds that have been uplifted at an angle greater than normal dip, and under present diastrophic strain, are apt to heave, or move by plastic flow into the area of least resistance, i.e., into the drill hole. The movement of these shales is aggravated by the lubricating effect of water from mud which penetrates along the bedding planes.

To combat this type of heaving shale it is necessary to increase the hydrostatic head of the mud and make it approach as nearly as possible the overburden pressure of the heaving-shale beds. In order to equal the average overburden pressure, a 21.7-lb.-per-gal. mud would be required. This is beyond the range of weights feasible with present weighting materials. Laboratory experiments on the use of galena (a lead ore with a specific gravity of 7.2) as a weighting material indicate that mud weights of the order of 22 lb. per gal. are possible, but the high cost of this ore probably will prohibit its use in most cases.

A few successful wells have been drilled through heaving shale of this type by the use of low water-loss muds which weigh from 14 to 18 lb. per gal. However, each well of this type is an individual problem, and the required mud weight for successful operations depends upon the degree of residual diastrophic strain in the particular area in question. Pressure drilling can be used to advantage in augmenting the mud weight on wells of this type.

Lost Circulation

The loss of mud to the formation is a trouble encountered frequently when cap material on shallow salt domes is drilled, and in normal drilling with heavy muds.

In the case of cap-rock drilling, the cause of lost circulation usually is a cavity in the rock, and usually it is necessary to set pipe through the zone causing trouble—although in come cases it is possible to plug these cavities by use of a quick-setting cement.

In most present-day drilling, however, the mud is lost to a porous low-pressure sand or gravel bed, and it is usually possible in this case to regain circulation by use of various mechanical plastering agents. Among those most commonly used are shredded cellophane, sugar-cane fibers, and mica flakes. These materials are added to the mud in the pit, and are pumped down opposite the zone to which the mud is being lost. Usually best results are obtained by the use of a combination of these materials.

It is necessary to remove the shale-shaker screens or to bypass the shaker in order to circulate these materials; for this reason it is undesirable to leave such materials in the mud for any great length of time. The usual procedure is to drill for 12 to 24 hours after circulation has been regained, and then to remove these materials by means of the shale shaker.

Also, the gel strength of heavily weighted muds should be kept low to prevent breaking down of the formation by the pump pressure required to break the gel and start circulation after a trip. If lost circulation has already occurred or is considered likely, it is advisable, on every trip with the drill pipe, to break circulation one or more times before reaching bottom in order to break the mud gel and reduce the initial pump pressure required to circulate on bottom.

When lost circulation has occurred, it is often possible, by the use of shredded cellophane, mica flakes, etc., to make the formation support a mud weight equal to that which originally caused the breakdown. However, in most cases this mud weight is very close to the upper limit. A small increase in mud weight above this point quite often produces a second breakdown which is more difficult to seal than the first. Therefore, it is advisable to set casing through the zone taking mud if

(*Continued on page 28*)

(Continued from Page 7)

Thacher was born in Kansas City, Missouri. He received an A. B. degree from Princeton University in 1930, and an M. S. from the Massachusetts Institute of Technology in 1942. He also studied at the San Francisco Law School.

From September 1925 to June 1926 Mr. Thacher was instrument man on a geological survey party conducted by the Roxanna Petroleum Corporation, of Okmulgee, Oklahoma. From November 1930, to June 1941, he was analyst for the gas division of the Standard Oil Company, with headquarters in San Francisco. In June, 1941, he held the Alfred Sloan Fellowship in Business and Engineering Administration, which led to his M. S. degree from M. I. T. in May 1942. The following month he joined the staff of WPB.

As technical consultant to the chief of the Natural Gas and Natural Gasoline Division, Mr. Thacher will chiefly be responsible for technical work incident to providing and maintaining supplies of natural gas for industrial and other essential purposes.

Directors Republic Supply Elect Officers

The directors of The Republic Supply Company of California have just announced the election of the following officers:

W. L. Duhig, President

J. J. Pike, Executive Vice President.

A. G. Fraser, Vice President

A. B. Ripley, Vice President & Treasurer

F. E. Wilkinson, Secretary

The directors are the same as the above named officers, plus W. D. Russell, and P. M. Pike, Chairman.

T. H. (Tom) Beament, former president of Republic Supply Co. is now a major in the Ordnance Department in the Army, headquartering in Washington, D. C.

E. P. Tallant

The appointment of E. P. Tallant as Chief Production Engineer for Union Oil Company has been announced by Ronald D. Gibbs, Manager of Field Operations. Tallant, who has been associated with Union Oil since 1917, replaces Howard C. Pyle, who has been called to military service.

Captain Pyle, a member of the U. S. Army Engineering Corps, recently entrained for Washington, D. C. where he will be stationed prior to making his headquarters in Louisiana.

W. L. Duhig

Cavins Co. Announce Change in California Representation

At Ventura, Joe Dabney, who has represented The Cavins Co. the past 7 years, has retired and after a vacation of a month or so plans on entering Defense work. His business has been taken over by Jesse Eubanks, who will henceforth be the Cavins representative in the Ventura territory. Jesse is well known to California oil men, having been employed for many years by the General Petroleum Corporation, in recent years as toolpusher. His new location is at 1641 North Ventura Avenue.

At Santa Maria, due to increasing business in connection with demands for heavy oil, a new agency has been established under the management of Lee Garrett. Lee is another old timer in the oil fields, well known to a great many people, having worked at various times in nearly every field in the State.

At Bakersfield, Fred Maze who has for many years represented the Cavins Co. in the San Joaquin Valley has sold out his interest and turned farmer, having acquired dairy and timber land near Hauser, Oregon. The Bakersfield territory is now under the direction of Leonard Moon, who has also represented the Cavins Co. in the Taft territory for several years. Moon will continue to direct activities at Taft and has appointed Walter "Spooks" Anderson to manage the Bakersfield branch.

All business addresses and telephone numbers at Bakersfield and Taft remain the same.

Standard Oil Co. Richmond Refinery Awarded "E"

Receipt of official notification of the Army-Navy "E" award by Richmond Refinery, Standard Oil Company of California, was announced on January 26th, 1943.

"The announcement of the award to the men and women of Richmond Refinery was made in a com-

(Continued on Page 20)

Field Development

Los Angeles Basin

Havenstrite Testing Del Valle Deep Try

R. E. Havenstrite, Opr., is testing water shut off on multiple zones in Barnes No. 2, sec. 16-4n-17w in the Del Valle field. Recent work effected a shut off over the Sherman zone at 5825 ft. and the Del Valle zone at 6505 ft. Last reported cleaned out to 8300 ft., the operator is preparing to perforate the interval 8060-7990 ft. for production trial.

On section 18 Herley & Kelley Handy No. 1 is repairing roads to resume testing. Bottomed at 5973 ft. the well is standing with 7 in. cemented at 5945 ft. which tested dry at 5570 and 5840 ft. Standard Oil Co. received approval for Sepulveda No. 5 to be drilled 330 ft. south and west of the east quarter corner corner of sec. 17-4n-17w.

L. A. City Test Under Way

Shell Oil Co.'s test of the old Salt Lake producing area near the corner of First and Gardner Streets in the City of Los Angeles is drilling at 1134 ft. after cementing 11¾ in. surface casing at 959 ft. The well, Verne Community No. 1, is employing a housed in derrick and full electric equipment to minimize noise and potential dirt nuisance. This measure was made necessary by the congestion of residences in the area.

Lompoc Well Cores Chert

Alphonzo E. Bell Corp.'s. Lompoc wildcat No. 6 on sec. 28-8n-34w is coring in oily chert at 4163 ft. Formation trials from 3300 to 3725 ft. indicated the presence of some oil and gas.

Tide Water Completes Aliso Canyon Well

Tide Water Assoc. Oil Co. Porter No. 18 bottomed at 5775 ft. to complete flowing 402 bbls. of clean 25 gravity oil through a 48/64 in. bean. The company's outpost try, Standard-Sesnon No. 2, southwest of the field limits, is grading for an immediate start.

Seaboard Plans L. A. City Drilling

In keeping with the urgent need for the development of additional crude oil reserves in the State of California, Seaboard Oil Company of Delaware has commenced to negotiate for a series of community oil and gas leases in the Elysian Park area and the old Los Angeles City field between Figueroa and Belmont Streets.

The Company plans to test and develop these structures in a series of community leases by drilling directional or slant holes from a single drill site within each of the community lease areas. It is planned to remove all derricks after drilling

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LOS ANGELES BASIN WILDCATS

Area	Well	No.	Section	Depth	Status
Chatsworth	J. Paul Getty, Foothill Orchards	1	6, 2-15	1430	Drilling
Las Llajas	West'n Gulf Oil Co., Brady	1	13, 3-17	7659	Cleaning Out
L. A. City	Schirm & Rubenstein H-S	1	24, 1-13	3919	Idle
	Shell Oil Co., Inc., Verne Comm.	1	21, 1-14	1134	Drilling
Newhall	Aztec Oil Co., Sanborn	1	6, 3-16	7266	Drilling
	James C. Brazell, Perkins	1	11, 3-16	4473	Idle
	So. Calif. Pet. Corp., Lassalle	44-1	3, 3-16	2715	Drilling
Puente	Barry Oil Co. Inc., Roland	1	14, 2-10	2365	Drilling
	Melvin Hansen, Dragna	1	24, 2-10	2840	Idle
Rio Hondo	Potrero Oil Co., Newman	1	32, 1-11	7111	Fishing D. P.
Whittier-La Habra	Los Nietos Valley Oil Co., Woodward	1	29, 2-11	3600	Idle
	H. & C. Oil Co., Joyce	1	22, 2-11	5065	Idle
	Orange County				
Buena Park	The Texas Co., B.P.U.	5-J-1	31, 3-10	4081	Drilling
Costa Mesa	Chas. W. Campbell	22	15, 6-10		Rigged up
Huntington Beach	Richfield Oil Corp., Weirick	1	7, 6-10		Bldg. Rig
Stanton	J E. F. Oil Co., Well	1	23, 4-11		Rigged up
	San Bernardino County				
Carbon Canyon	Stella, E. F., McDermont	2	5, 3-8	1085	Bailing
Colton	Supreme Oil Co., Well	1	2, 2-4	764	Drilling

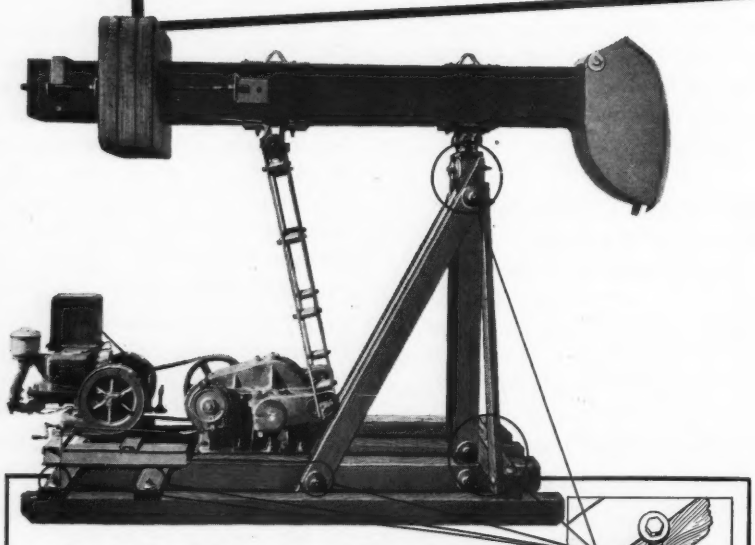
is completed so that the surrounding residential areas will be protected so far as practicable from unsightly structures. All operations are to be conducted in conformity with City, State and Federal regulations which will prescribe the methods to be used to protect the surrounding property from noise, dust, vibrations and other potential nuisances.

Two Work In Newhall Area

Southern California Pet. Corp.'s wildcat near the main Ridge highway on sec. 3-3n-16w is drilling at 2715 ft. while Aztec Oil Co.'s try south of the Newhall-Potrero field is drilling hard dark shale at 7266 ft.

Engineering, Technology, latest news—twice a month in California Oil World.

PACIFIC OIL WELL
Timber PUMPING UNITS



STRUCTURALLY SOUND THROUGHOUT

PACIFIC Timber Pumping Units are designed to give life comparable to steel. Solid joints between wooden members are obtained by use of steel timber connectors. This means more than just bolting. Bolts merely hold the members firmly together, while the large, concentric, annual, inset, steel rings maintain permanent rigidity at the joint.

Chemical impregnation of the wood members makes them termite proof.

The name PACIFIC on the herringbone reducer is a guarantee of stability and thorough workmanship.

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ASSOCIATED COMPANIES:

WESTERN GEAR WORKS—Lynwood, California
PACIFIC GEAR & TOOL WORKS—San Francisco
WESTERN GEAR WORKS—Seattle, Washington

(Continued from Page 18)

munication from Hon. James Forrestal, Under Secretary of the Navy, to H. D. Collier, President of Standard Oil Company of California.

"Under Secretary Forrestal said in part, 'Your record of practical accomplishment is high, your production effort outstanding, and you have good reason for pride in both.' "

"Mr. Collier, commenting on the announcement said, 'More than 3,000 men and women are employed at Richmond. Each and every one has made a substantial contribution to the output and efficiency of the plant. We are indeed proud of them, and I know that this recognition of their great contribution to victory in this way for human liberty will serve to spur them on to meet and exceed the greater demands arising from the war effort.'

"The formal presentation ceremony will take place at Richmond, California during the month of February. Army and Navy officers will present the award which consists of a flag to be flown above the Richmond Refinery, and a lapel pin for each employee. The date of the ceremony will be announced upon advice from the Navy."

Modern Oil Engine Practice

E. Molloy. 636 pages, 1943—$5.00.

Dealing with Principles and Construction, Operation, Maintenance and Servicing of the leading types of Stationary, Marine and Automobile Diesel Engines, with Notes on Rail, Traction and Aero Diesel Practice.

This book provides an up-to-date survey of the various types of compression ignition or Diesel engines now available. The greater portion of the space has been devoted to stationary and marine types, but automobile, locomotive and aero oil engines have all received adequate treatment.

Published by Chemical Publishing Co., Inc., Brooklyn, New York.

Coastal District

Shiells Canyon Well Pumps Clean

Seaboard Oil Co.'s Seaboard-Calumet No. 1, sec. 10-3n-19w, demonstrated its productivity when it pumped and flowed by heads clean 30 gravity oil at an estimated 150 bbl. rate. Bottomed at 3292 ft. after taking in considerable sand the well appears to be a valuable addition to Coast field reserves. The company is preparing to drill it's second test 1000 ft. north and 2750 ft. east of the southwest corner of section 3.

Three Work At Rincon

Following Honolulu Oil Corp.'s good completions in Miley zone of the Rincon field, Richfield Oil Corp. is preparing to redrill the Miley zone in Hobson U. S. No. 2. C.C. M.O.Co. is whipstocking it's redrill of the 4521 ft. Hobson No. B-10A to the southwest at 1812 ft. The company's No. B-45 is newly spudded aind drilling near 500 ft.

Gasser Completed In Contra Costa Co.

South of the Rio Vista Gas field on sec. 29-3n-3e in the Jersey area of Contra Costa county, Standard Oil Co. completed Jordan Unit No. 1 flowing 16,835,000 cu. ft. of gas. Bottomed at 4270 ft. the gasser entered the Green sand at 4153 ft. and the White sand at 4264 ft.

Union To Test Ciervo Wildcat

Union Oil Co. is preparing to test Friedman No. 1 on sec. 13-16s-11e of San Benito county. Bottomed at 6370 ft. the well twisted off and while fishing twisted off the wash pipe. Failing to recover the fish below 6030 ft. the operators landed 5½ in. casing including 2131 ft. of perforation at 6006 ft. and cemented through perforations at 3850 ft. Formation tests below 4000 ft. on the way down recovered small amounts of gas with a heavy gasoline odor and some gas cut mud.

Joint Test In Lodi Area

Amerada Pet. Corp. is grading roads in sec. 9-4n-7e in the Lodi area of San Joaquin county for No. 9-1, a wildcat to be drilled as a joint test with Bankline and Honolulu Oil Co.'s, all of whom leased heavily in the area.

O. C. Field Grading Gato Ridge Site

O. C. Field is grading location for Texas Fee No. 2 on a site 212 ft. southwesterly and 1523 ft. westerly from Corner No. 3-A of the Los Alamos Rancho in sec. 4-8n-32w. The Petrol Corp. also plans to drill a spot on approximately the same contour in the event the Field well effects production. It is considered advisable to conserve steel stocks and labor in accordance with government wishes until such time as the earlier well demonstrates its potentialities.

Three Work Piru Area

Three strings are currently working with more projects scheduled in the Piru Area of Ventura County. Nearest completion is Pacific Western Oil Corp.'s Temescal No. 15 on sec. 4-4n-18w which is finishing at 3192 ft. Continental Oil Co.'s Holser No. 2, sec. 14-4n-18w is drilling in hard shale at 3975 ft., while Tide Water Assoc. Oil Co.'s Hidden No. 2 on sec. 5-4n-18w is making hole in hard sand with deep dips at 3447 ft.

COASTAL COUNTIES WILDCATS

Area	Well	No.	Section	Depth	Status
	Santa Barbara County				
Cat Canyon	Bel-Air Oil Co., Williams	1	25, 9-33	6291	Plugging
	Standard Oil Co. SBLC	1	15, 9-33	7250	Testing
Gato Ridge	General Pet. Corp. Wickeden	2	24, 8-32		Location
Goleta	Del Mar Oil Co., Rowe	1	11, 4-28	2470	Drilling
Lompoc	Alphonzo E. Bell Corp., Lompoc	6	28, 8-34	4163	Drilling
	Fickert Oil Co., Ltd., Well	1	8, 7-33		Rig
Los Olivos	TideWater A. O. Co. Chamberlin	1	33, 8-31	4009	Drilling
	Ventura County				
Bardsdale	Los Nietos Co., Elkins	1	6, 3-19	5681	Fishing W. P.
	San Marino Oil Co., Elkins	1	7, 3-19		Rig
Conejo	L. A. Basin Oil Co. Well	1	4, 1-20	1745	Idle
	Sycamore Oil Co., Boylan	1	23, 1-20	2747	Idle
Ojai	Coates, Spencer D., Pirie	5	7, 4-22	1033	Idle
Piru	Continental Oil Co., Holser	2	14, 4-18	3975	Drilling
	Delroy Pet. Corp., Fisk C. H.	1	22, 5-18	2802	Idle
	Pac. West. O. Corp. Temescal	15	4, 4-18	3192	Completing
	T.W.A. Oil Co., Hidden	2	5, 4-18	3447	Drilling
Sespe	McCaslin, W. E., Burson	1	19, 4-19	2039	Idle
	Volunteer Pet. Co., Tar Creek	3	28, 5-19	540	Idle
Timber Canyon	Crude Oils, Inc., West	1	19, 4-20	958	Idle
	Fletcher & Babcock O'Leary	1	29, 4-20		Location

NORTHERN COUNTIES WILDCATS

County	Well	No.	Section	Depth	Status
Butte	Pac. West'n & Getty Cana	1	11,23n-1w	5808	Drilling
	Superior Oil Co., Dodge Land	1	30,20n-1e	7175	Drilling
Contra Costa	Standard Oil Co., Jordan Unit	1	29, 3n-3e	4270	Completed
Monterey	Loma Grande Oil Co., Corey	1	23,24s-10e	4318	Idle
	Columbia Oil Co., Vierra	1	7, 13s-2e		Rig
Sacramento	D. D. Feldman, Unit Plan	1	8, 7n-6e	2450	Drilling
	Richfield Oil Corp. Natomas	1	17, 10n-4e		Location
San Benito	Union Oil Co., Friedman	1	13,16s-11e	6370	stdg. cemented
San Joaquin	Standard Oil Co., Blewett Com.	3	23, 3s-6e		Rig
San Luis Obispo	W'n Gulf Oil Co., Huasna Comm	1	35,31s-14e	104	Drilling
Solano	Los Nietos Co., Holmes	1	6, 32s-14e	2525	Drilling
	Amerada Pet. Corp. Starkey Fee	1	2, 6n-2e		Rigging up
	Peter Cook, Jr., Peter Cook	3	8, 4n-3e	4452	Abandoned

Texaco Starting New Gas Well

The Texas Co. is preparing to start Welch No. 3 as an additional gas development in the Rio Vista Gas field. The latest effort is located in the approximate center of sec. 32-4n-3e.

Peter Cook Jr.'s attempt to find production north of the Field on sec. 8-4n-3e failed when his No. 3 was abandoned in hard shale at 4452 ft. without having found the productive green sands.

Los Olivos Coring Miocene

Tide Water Assoc. Oil Co.'s Chamberlin No. 1, sec. 33-8n-31w, offset to the company's newly discovered production in the Los Olivos Area of Santa Barbara County is coring Miocene shale at 4,009 ft.

Two Wells Starting In Cat Canyon

Two projects are underway in the Cat Canyon of Santa Barbara County. The projects which are each grading are Pacific Western Oil Corp.'s Los Alamos No. 20 on sec. 36-9n-33w and Union Oil Co.'s Bell No. 16 in the same section.

Nomads January Meeting

Officers for the year 1943 were elected at the Annual Meeting of the Los Angeles Chapter of Nomads held in Los Angeles, Wednesday evening, January 13, 1943. Ballots were opened at a business session preceding the regular dinner by past presidents of the Chapter, Elmer Decker and Ted Sutter. The result of the voting was: Henry Pullman, president; Roland Smith, vice-president; Wallace A. Sawdon, secretary; Tom Martin, assistant secretary; Elmer Smith, treasurer; Roger Henquet, assistant treasurer; J. V. Robinson, sergeant-at-arms; George Trembley, deputy sergeant at arms.

The National Regents elected to represent the Chapter on the Board of Regents of the Nomads were W. (Bill) F. Bettis and W. R. (Frosty) Martin. Plans for the Fourth Annual Inaugural Ball to be held in February were then discussed and H. E. Cassidy, Lew Bronzan and Wallace Sawdon were appointed by President Bettis to aid the Entertainment Committee consisting of Roland Smith, chairman, and J. V. Robinson in making final arrangements for this affair.

The speaker of the evening was Boyd Comstock who was introduced by Lew Bronzan, master of ceremonies for the meeting. Mr. Comstock was the Olympic Coach and Director of Athletics in Italy for a number of years before war was declared between Italy and the United States. When war broke out he had the job of getting back home but after being exchanged finally reached this country on July 4, 1942. His remarks were devoted to the Italian situation and to the hardships being endured in Italy, particularly under the present German control.

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San Joaquin Valley

Guijarral Well Makes Oil Flow

Standard Oil Co.'s Guijarral Hills wildcat, Pleasant Valley No. 82-29F in sec. 29-20s-16e, bottomed in oil sand at 9031 ft. after cementing 7 in. casing over the top of Eocene sands at 8942 ft. A 4-3/4 hour formation test from the shoe to bottom flowed to the tanks for three hours at a 1525 bbl. rate through a ½ in. bottom hole bean and a 1 in. orifice at the surface. Thought to be a shoreline accumulation the indicated new field produces 27.7 gravity clean oil. The company is now coring at 9050 ft. to determine the thickness of the section before completing.

Nicholson Well Going on Hook

The Shell-Standard Oil Co. wildcat, Henderson No. 66-22 in sec. 22-15s-15e of Fresno county, is being abandoned in siltstone and streaks of gray sand at 12,018 ft. Some gas shows were found during drilling with nothing worthy of testing being encountered.

Mendota Well Nears Basement

The Texas Co.'s Gill No. 38-16, sec. 16-13s-16e in the Mendota area inside the Madera county line, was last reported coring in conglomerate at 9050 ft. Logged to 9020 ft. the well will carry to true basement complex. Lacking discovery in the basal section the well will be plugged for further trial of Eocene sands below 4400 ft.

Dunlap To Test Dyer Creek Sands

D. D. Dunlap's Dyer creek wildcat No. 1 on sec. 11-26s-27e offers promise of duplicating adjoining production discovered by Shell Oil Co., Inc. The well bottomed in oil sand at 2293 ft. after entering the Vedder at 2280 ft. and is standing with 6 5/8 in. casing cemented at 2275 ft. Only the top of the zone will be tested at first since prior drilling in the area has demonstrated the lower sections of the horizon to be wet.

Di Gorgio Starts New Mt. View "Cat"

Di Giorgio Fruit Corp. is ready to continue it's search for oil off the Mountain View field with well No. 3. Located in the southeast quarter of sec. 7-31s-30e the well was preceded by two efforts in the area which bottomed in basement rock without commercial showings.

Helm Well Recompleted

Amerada Pet. Corp. recompleted Weyant No. 37-27 in the Helm field in the perforated intervals 7468-78 & 7455-7480 ft. flowing under control at 183 bbl. rate. The 58.6 gravity condensate was obtained through a 22/64 in. bean along with 4,023,000 cu. ft. of gas. The company is preparing to spud Clover No. F-1-28 on sec. 28-16s-17e.

Shallow Work Yet Continues

A consistent shallow development program is continuing in the Buena Vista, South Belridge, Coalinga, Kern Front, Poso Creek-Premier, Midway-Sunset, Mount Poso, Round Mountain and Williams-Antelope Hills fields. Recovery in these areas is small but the shallow depth, requiring little tubular goods, when balanced against the good quality heavy oil recovered makes such development an extremely good war-time operation.

Univ. Cons. Pumps Lost Hills Well

Universal Cons. Oil Co. completed well No. 20-D on the pump at 1692 ft. for 36 bbls. daily 17.2 gravity oil. In the same section 30-26s-21e the company is drilling well No. 21-D at 910 ft.

Greeley Well Nears Productive Horizon

Standard Oil Co.'s KCL No. 11-36, sec. 20-29s-26e, which is the first Greeley field development during

SAN JOAQUIN VALLEY WILDCATS

Area	Well	No.	Section	Depth	Status
	Fresno County				
Coalinga	Carrie Estelle Doheny, et al Lobre	43-24A	24, 19-15	3596	Drilling
Jacalitos	Standard Oil Co. Well	61-35	35, 21-15		Grade
Guijarral Hills	Standard Oil Co., Well	82-29F	29, 20-16	9031	Testing
Kingsburg	Superior Oil Co., White	1	29, 16-22	4168	Drilling
Nicholson	Shell-Standard, Henderson	66-22	27,15-15	12018	Abandoning
	Kern County				
Antelope Hills	C.C.M.Co. Antelope Fee	12-1	12, 28-19		Location
	Shell Oil Co., Inc. Fee	78-31	31, 27-20	1660	Drilling
Bowerbank	The Texas Co., Bowerbank	1-6-C	6, 29-24		Rigging up
Canfield Ranch	Shell Oil Co., Inc. KCL	84-27	27, 30-26		Rigging up
Comanche Point	T. W. Burnham, Chiquita	2	34, 12-19	1109	Drilling
Cymric	Los Nietos Co., Sheep Springs	1	20, 29-21		Rig
	C. M. Morse, O'Donnell	1	13, 29-21	1240	Abandoned
Dyer Creek	D. D. Dunlap, Dyer Creek	1	11, 26-27	2293	Testing
Kern Front	Richfield Oil Corp. M & K Fee	1	33, 28-27	3010	Abandoned
Midway-SE.	The Texas Co., P.U.P.	2	33, 11-23	9895	Drilling
Mt. View	DiGiorgio Fruit Corp., Well	3	7, 31-30		Location
Round Mt.	Gen. Pet. Corp., Railroad	1	23, 28-28		Foundation
	Harp & Brown, Olcese	1	17, 28-29		Rig
	Iseminger Bros., Well	1	2, 28-28	1115	Fishing D. P.
Strand	T.W.A.O. Co., KCL	76-8	8, 30-26		Grading
	T.W.A.O. Co., KCL	32-17	17, 30-26	941	Drilling
	Kings County				
Hanford	Continental Oil Co., Drummond	2	36, 18-22	5401	Abandoning
Tulare Lake	Shell Oil Co., Inc. T.S.G.	21-28	28, 22-20	8838	Drilling
	Madera County				
Mendota	The Texas Co., Gill	38-16	16, 13-16	9050	Drilling
	San Luis Obispo County				
Midway, NW.	C.C.M.O. Co., Thomas	1	1, 31-21	7579	Drilling

wartime, is nearing the productive horizons. Now drilling at 10,133 ft. the well will finish in the Vedder zone near 11,500 ft.

Kenda Well To Sidetrack Fish

Kettleman North Dome Association twisted off drill pipe in No. 333-18Q at 8331 ft. and is plugging to sidetrack the fish from 7594 ft. The Association's No. 343-24H is fishing after bottoming at 10726 ft.—redrilling to 9635 ft. and again twisting off drill pipe. Standard Oil Co., only other operator in the North Dome field, is drilling No. 61-35Q at 5800 ft. in brown shale.

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A. A. P. G. Hear Dr. Kellum

The first of a series of lectures pertaining to the exploration for new supplies of petroleum was delivered by Professor Lewis B. Kellum of the University of Michigan before the regular monthly meeting of the Pacific Section, American Association of Petroleum Geologists, on Tuesday evening Jan. 26 at the L. A. Athletic Club. His subject was "The Geologic History of North Central Mexico and Its Bearing on Petroleum Exploration."

Dr. Kellum, who spent 4 years in exploration work in Mexico for a major oil company prior to joining the faculty and has since devoted a large part of his time in the direction of geological work in Mexico and New Zealand, is one of a group of speakers chosen by the Distinguished Lecture Committee of the American Association of Petroleum Geologists and sponsored jointly by the Pacific Section and the Association. The committee was organized about 1 year ago for the specific purpose of recommending and sponsoring a group of qualified petroleum geologists to lecture before the various Sections and Affiliated Societies of the Association. It is believed that the broad experience of those chosen and the chance for the members in different parts of the country to discuss with them the myriad problems of oil exploration will be of value to the petroleum geologist, whose responsibility of finding new supplies of petroleum throughout the world has increased many fold because of the drain on known reserves by the war.

The American Association of Petroleum Geologists was organized in 1917 for the purpose of promoting the science of geology as it relates to the exploration for and production of petroleum and natural gas. It now has a membership of about 3,800, of whom nearly 500 were located in the Pacific Coast states and were members of the Pacific Section. Prior to the disruption caused by the war, members of the Association were working throughout the United States and in 52 countries outside the United States. Judging from a recent survey, no less than 400 members are in the service of the armed forces, many of them in special branches for which their training as geologists and experience in exploration work makes them of particular value. Officers of the Pacific Section are: President, Max L. Krueger, Union Oil Company of California, Los Angeles; and Secretary-Treasurer, Richard Ten Eyck, Continental Oil Company, Los Angeles.

A. G. Melville Reenters California Oil Game

A. G. Melville, for the past two years engaged in Arizona Mining operations, has reentered the California Consulting Geologist field, with offices at 1114 Second Street, Manhattan Beach. Mr. Melville represents interests engaged in the acquiring of drilling sites for immediate work. He is delighted to be back and looks forward to seeing the many friends earned in 20 years of California operations with such companies as C.C.M.O., Barnsdall, Ohio and California Lands.

SALE OF OIL ROYALTIES

Selected and diversified royalties located in or near Southern California. Signal Hill, Huntington Beach, Santa Fe Springs, East Coalinga, Santa Maria, etc. Cost $353,841.01. Estimated values as of October 5, 1942, $166,272.00. Sale in the case of In re Diversified Royalties, Ltd., No. 35,565-B, U. S. District Court, Southern District of California, before Special Master Brink, Room 327, Federal Bldg., Temple and Spring Sts., Los Angeles, Thursday, Feb. 25, 1943, at 10:00 A.M. Sale as a whole, or in separate units, or in parcels. Terms cash, or special terms approved by the court. Right reserved to reject any and all bids. Lists will be furnished upon application. For further information, inquire of Reuben G. Hunt, Trustee, preferably by mail, 838 H. W. Hellman Bldg., 354 So. Spring St., Los Angeles, phone TRinity 0649.

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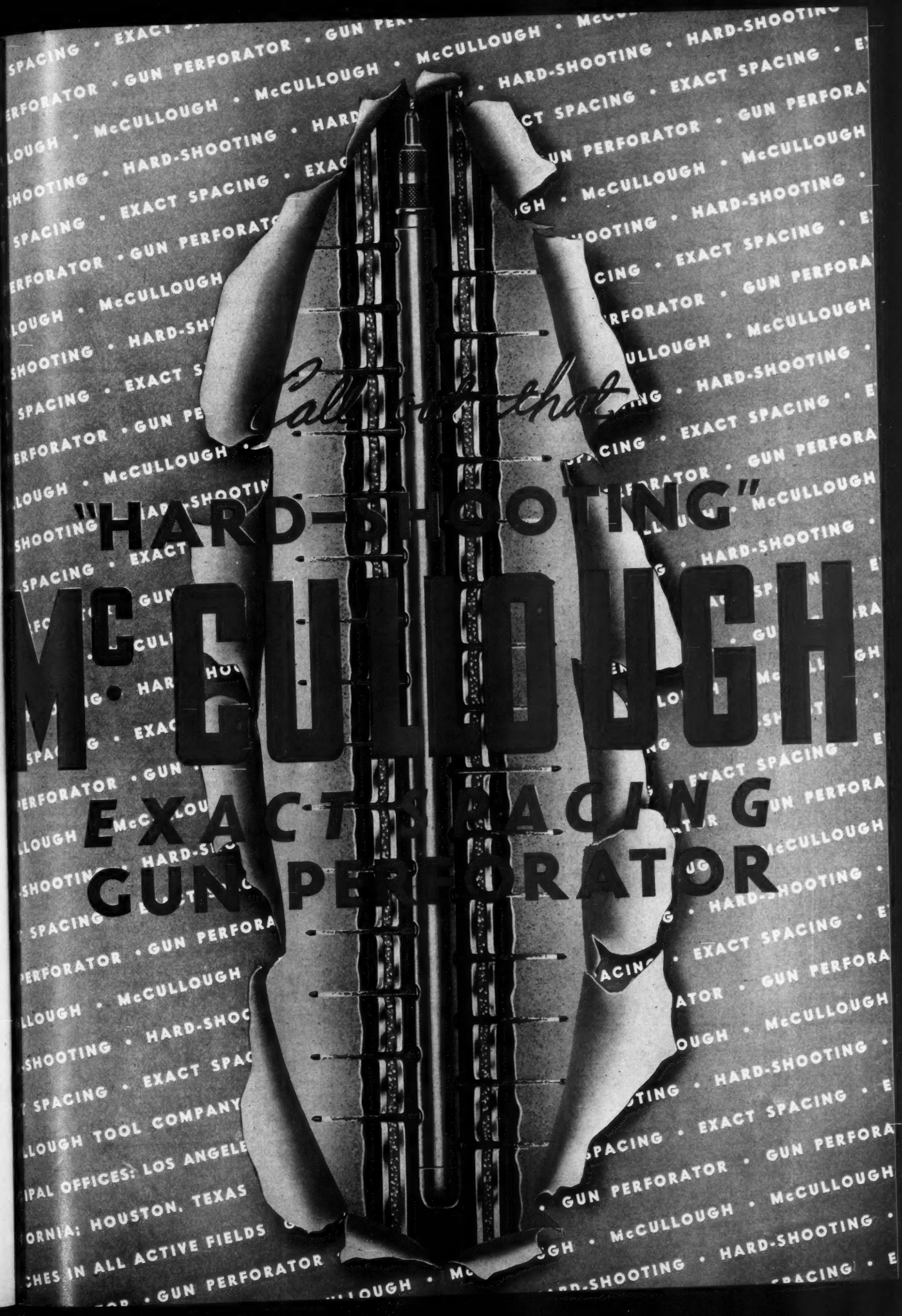
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THIS LAUGH

OFF!!

They tell the tale of the man to whom three wishes were granted. He wished first that he might have 100 suits of clothes. There was a rustling in the closet; when he opened the door, hanging there were 100 suits.

He wished that he might have $1,000,000. There was a rustling in a desk drawer; when he opened it, there were the banknotes—$1,000,000 in all.

"Now," he said, "I have but one wish left. I wish that I might meet Hitler."

The telephone bell rang. He answered.

"This," said the voice on the other end, "is your Draft Board. You're in 1-A."

* * *

A modern girl is one who can meet the wolf at the door and come out with a fur coat.

* * *

The newly elected member of the senate was chided by the old-timer:

"You did not make the most of your opportunities."

"What opportunities?"

"The opportunities you had of sitting down."

* * *

Wife (to drunken husband — "I suppose you expect me to believe that you came right home from the office?"

Husband—"Sur did, (hic) straight as the crow flies."

Wife—"So I see. Stopping frequently for a little corn."

* * *

Mary had a little lamb
plus coffee and dessert
She gave the Sarge the wrong address
the tricky little flirt.

* * *

He: "I'd go through fire for you.
She: What a silly ash you'd be.

Their cars having collided, Jock and Pat were surveying the situation. Jock offered Pat a drink from his bottle. Pat drank and Jock returned the bottle to his pocket.

"Thank ye," said Pat, "but aren't ye going to have a nip yourself?"

"Aye," replied Jock, "but not until the police have been here."

* * *

Navy Bill had broken with his girl friend. After ignoring several letters requesting the return of her photograph, one came threatening to complain to the captain. Deciding to squelch her for all time, he borrowed all the pictures of girls available on the ship, sending them to her in a large bundle with the following note:

"Pick yours out; I've forgotten what you look like."

* * *

"I want to die with my boots on," boasted the gent. And the redhead purred, "Well, put 'em on! Here comes my husband."

* * *

And then of course, there was the optician's daughter. Two glasses and she made a spectacle of herself.

* * *

A bashful young darky had not the courage to pop the question. Finally one Sunday night, he said:

"Julia, yo' remembers that I was heah Monday night?"

"Yes," Julia replied.

"An dat I was heah Wednesday an' Thursday?"

"Yes."

"An once mo' on Friday an' again las' night?"

"Sho yo' was."

"An' I is heah tonight?"

"Yo' sho' is."

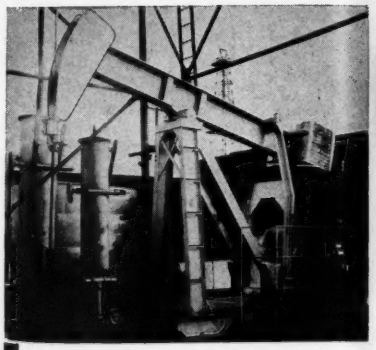
Then in desperation, he burst out with,

"Say, woman, doesn't yo' smell a rat?"

Mess Sergeant: Who in —— put those darned flowers on the table?

Private: The captain did.

Mess Sergeant: Purdy, ain't they?



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Untreated Steel Pumps	150 to 170	6 to 14-C

"GROOVE SEALS" are unmatched for maximum low-cost production

TO PRODUCE a pump that will outperform others in the same price class is, in itself, an important accomplishment. But to produce a pump that actually outperforms pumps selling at a much *higher* price is a real achievement.

Yet that's exactly what we have done in the new Flupaco "Hardened and Honed Groove Seals." What's more, "Groove Seals" are not just one-condition, one-depth pumps. They handle *any* job in the field where an insert (rod) type pump can be used—regardless of type of crude, volume depth, corrosion, abrasion, etc.—and have the largest cross-sectional displacement in insert pumps.

THE VOLUME PRODUCER handles a wide range of problems such as large volumes and deep pumping, sand conditions and corrosion, light and heavy oils.

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SAVING the cost of drilling new wells and making the most out of existing wells is made possible by the new, quality "Petrol A" Pumps, which can be... (1) installed at low first cost... (2) operated on minimum power... (3) depended upon for uniform production and long, trouble-free life.

"Petrol A" Pumps can be anchored to old liner barrels without pulling tubing. They can be made to run in 1½" insert tubing and are available in Top and Bottom Lock Types.

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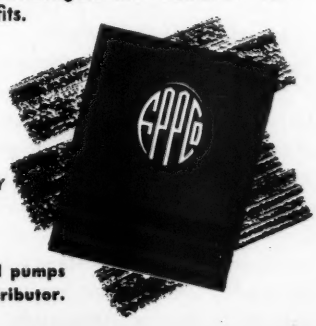

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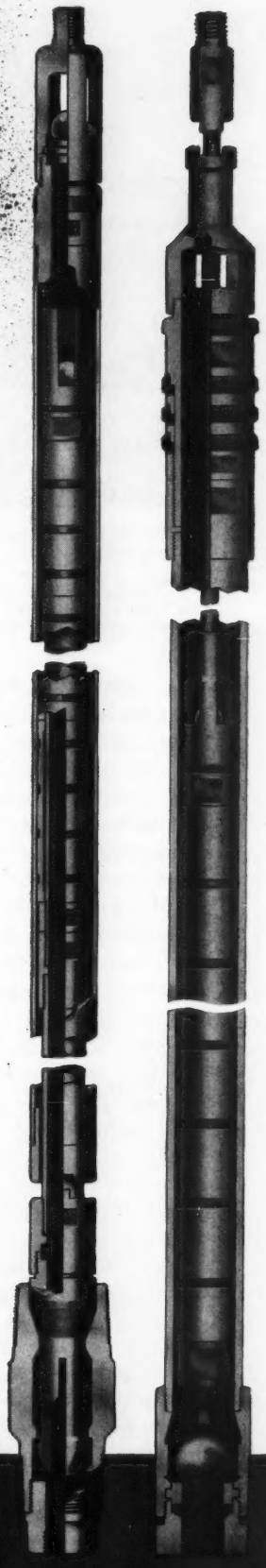

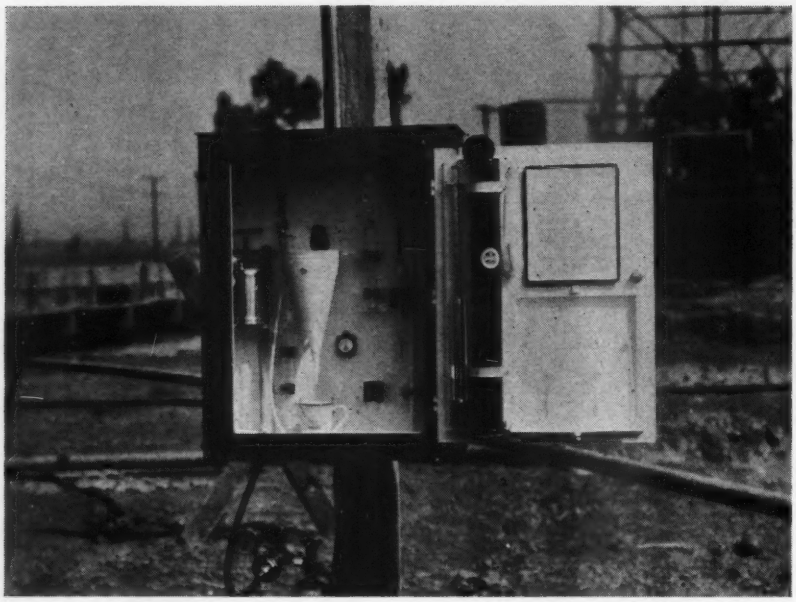

This unit provides neatly arranged equipment for the mud man's full convenience.

(Continued from Page 17)

further weight increases are anticipated.

Preventive Measures

On the Gulf Coast of Texas and Louisiana there are thick beds of sand in the Miocene which have been found by experience to take mud under moderate pressures. Consequently, it is advisable to set a protective string of casing through the Miocene sand beds whenever it is necessary to use a mud weighing more than 13 lb. per gal. in drilling the deeper formations.

It also has been found in certain areas where lost circulation in a definite zone has occurred on previous locations that a pretreatment with small quantities of the usual plastering agents is of value. The usual procedure is to add a few hundred pounds of the plastering agent to the mud just prior to drilling the zone in which lost circulation is expected. Circulation of the plastering agent is continued for about 24 hours after drilling the zone, after which the shale-shaker screens are replaced and the plastering material removed.

The explanation offered for this procedure is that it is easier to plaster crevices in the formation before a breakdown occurs than it is to seal off a zone already taking mud. In some cases this procedure seems to have merit. However, it is often not possible to anticipate the occurrence of lost circulation, as is necessary to this procedure.

High-Temperature Decomposition of Phosphates

Many of the viscosity-reducing chemicals now in common use depend for their effect on the dispersing action of the complex phosphates. These complex phosphates are salts obtained from the simple (ortho) phosphates by dehydration. Tetrasodium pyrophosphate, for example, may be produced by the following reaction:

$$2\ Na_2HPO_4 \xrightarrow{Heat} Na_4P_2O_7 + H_2O$$

Unfortunately, this reaction is reversible in the presence of water, and the rate of reversal increases rapidly with temperature within the range of normal mud temperatures. Hence, in very deep wells, or in drilling near shallow salt domes, when abnormal temperatures are encountered, these complex phosphates are decomposed almost completely in one circulation of the mud, and constant additions of relatively large quantities of the complex phosphates are required to keep the viscosity within satisfactory limits. Furthermore, the decomposition products of some of the more common complex phosphates are strongly acidic, and tend to reduce the pH of the mud below desirable limits.

The flow-line temperature may be used as a rough measure of the bottom-hole temperature in deciding when to expect this trouble, as these two temperatures vary in more or less direct proportion. However, the spread between the bottom-hole and flow-line temperatures increases with the depth of the hole. Hence, the phosphates normally will occur at lower flow-line temperatures on deep wells than on shallow wells. In general, a flow-line temperature of 120 deg. F, or above, indicates a bottom-hole temperature sufficiently high to cause this trouble.

Corrective Chemical Treatment for High-Temperature Decomposition of Phosphates

In the early stages, a mixture of equal proportions of Quebracho extract and one of the phosphates sometimes will maintain a satisfactory viscosity, and the use of Quebracho has the added advantage of reducing the water loss of the mud. However, Quebracho is capable of reducing the initial and 10-min. gel-strength values so low as to allow settling of cuttings and weighting material on muds having a low pH; and as, the decomposition products of many phosphates tend to lower the mud pH, this mixture must be used with caution. The use of salt as suggested by Loomis, Ford, and Fidiam[5] probably would be of advantage in maintaining satisfactory gel strength under these conditions, but the author knows of no case in which salt has been used.

An organic compound, dicyandiamide, for use in high-temperature muds recently has been placed on the market.[6] This compound, $NH_2C(:NH)NH\,C:N$, is said to stabilize the phosphates as well as to reduce the viscosity and gel strength of high-temperature muds. As this chemical has been in use only a short time, much remains to be

learned of its reactions. However, very satisfactory results have been obtained by its use in combination with the phosphates and Quebracho on some of the deep wells recently drilled on the Gulf Coast of Texas and Louisiana. The procedure recommended by the manufacturers is to add dicyandiamide rapidly to a mud already containing phosphates, up to a concentration of about 0.5 lb. per bbl. of mud, and then to use a combination of phosphates, or Quebracho, and dicyandiamide as required to maintain satisfactory viscosity.

Dicyandiamide, like Quebracho, has been known to reduce the gel strength below desirable limits when too much was used. Therefore, the gel rate and gel strength should be observed carefully during its use.

Phosphorus and the phosphates are used extensively in modern warfare. Therefore, it is quite possible that the industry may be unable to obtain the necessary supply of phosphates for mud control in the future. In that event, it will be necessary to make more extensive use of organic materials such as dicyandiamide, gallic acid, and Quebracho as substitutes for the complex phosphates, and to use sodium bicarbonate or soda ash where we now use the simple orthophosphates.

High Concentration of Collodial Matter

In the course of drilling, beds of bentonitic shale sometimes are encountered which disperse rapidly into the mud system and increase the viscosity and total-solids content of the mud. The rate of dispersion may not be high enough to place them in the class of bentonitic heaving shales, but the accumulation of colloidal material makes viscosity control difficult.

Dilution with water will reduce the viscosity of any drilling mud, and it is, therefore, a temptation for the field engineer to control difficult muds by excessive use of water rather than by proper chemical treatment based on a correct diagnosis of the actual cause of the trouble. Water is a very expensive "chemical" to use on heavily weighted muds. For example, it requires about 600 lbs. of barytes to increase the weight of 1 bbl. of water to 16 lbs. per gal., whereas the cost of chemicals required to produce the same viscosity reduction is usually much less. We should make certain that the colloid concentration is too high before adding the large volumes of water and weighting material necessary to correct it.

Prevention by pH Control

Frequently the high concentration of colloid material may be prevented in part on heavy muds by proper chemical treatment **before** the bentonitic shale is encountered. As mentioned previously, the rate of dispersion of shales into the mud stream increases with increasing mud pH, showing a sharp increase in the range of pH 9 to 11 for most shales. Therefore, it is important in drilling bentonitic shales with heavily weighted muds to adjust the pH of the mud system within the range of pH 7.5 to 8 in order to retard the dispersion of bentonitic shale as much as possible. pH values lower than 7.5 probably would further reduce the rate of shale dispersion, but are not recommended because of the instability of acid muds and the increased corrosion of the drill pipe. A pH range of 8.0 to 9.5 is recommended for all ordinary drilling, but the lower pH values are useful when heavily weighted muds must be used.

Corrective Chemical Treatment for High Concentration of Colloids

Muds containing excessive amounts of bentonitic shale will show a high viscosity with **a low water loss.** If the water loss is relatively high, the trouble is probably due to soluble calcium salts rather than to excessive amounts of bentonite, and the treatment should be selected accordingly. The only successful treatment for excessive concentrations of bentonite is dilution with water and the addition of weighting material to maintain the required mud weight. This is an expensive treatment, but is necessary if large sections of bentonitic shale are encountered.

CONCLUSION

An attempt has been made to rationalize the causes and "cures" of various mud problems on the basis of theoretical considerations. It is believed that a more thorough application of the fundamental principles of colloid chemistry in the field treatment of drilling muds, as opposed to the more common trial-and-error methods of the past, will pay dividends in economical and less troublesome drilling operations.

Often a treatment which gives temporary relief from a particular mud problem may itself cause more serious difficulties at a later date. Therefore, an attempt should be made to look ahead in mud treatment, and to prevent the occurrence of trouble whenever possible. Credit is due the engineer who quickly and economically can correct mud troubles which endanger or delay the drilling operation, but even greater recognition should be given to the less spectacular efforts of those who, by foresight, avoid these costly delays and difficulties.

Closer cooperation between the research and the field engineers is necessary if rapid improvement in field mud-treatment methods and the fullest utilization of research data are to be achieved.

APPENDIX

The following is an outline of the ordinary mud troubles, their "symptoms," and the methods of treatment most commonly used for their correction. There is included also a list of the most common mud-treatment chemicals, with their pH values in the concentrations ordinarily used in mud treatment. This list of chemicals was furnished by Arthur G. Levy, of the Fohs Oil Company, and is presented with his kind permission.

Cement Contamination

"Symptoms"

1. Increased gel rate and gel strength.
2. Increased pH.

3. Increased viscosity.
4. Increased water loss.

Chemical Treatment

1. Mixture of monosodium phosphate and complex phosphate, or sodium acid pyrophosphate alone, until pH returns to value, before contamination.
2. Add collodial clay slowly, with continued use of complex phosphate to control viscosity, until water loss and gel rate return to normal.

Soluble Calcium Salts

(Lime, gypsum, anhydrite, etc.)

A. In drilling limey shales with natural drilling mud:

"Symptoms"

1. Mud viscosity usually low.
2. Rapid gel rate, weak gel strength.
3. Practically no new mud formed from shales drilled.

Chemical Treatment

1. Add soda ash (alkaline), or disodium phosphate (neutral), depending on initial pH, until viscosity begins to rise. There will be little if any improvement in mud properties until treatment is practically complete. Then viscosity and gel characteristics improve rapidly.
2. If gel rate is still too high after viscosity increases to desired value, use mixture of soda ash or disodium phosphate with sufficient complex phosphate to control viscosity until gel rate is satisfactory.
3. Colloidal-clay additions may be required to give satisfactory wall-building characteristics.

B. In drilling beds of gypsum, anhydrite, etc. (large quantities of soluble calcium salts suddenly encountered):

"Symptoms"

1. Increased gel rate and gel strength.
2. Increased viscosity.
3. Increased water loss and cake thickness.

Chemical Treatment

1. Use mixture of disodium phosphate and complex phosphate to remove calcium and control viscosity.
2. Add fresh bentonite as required to hold required water loss.
3. Quebracho useful in reducing gel rate.

High-Pressure Gas

"Symptoms"

1. First indicated by minute gas bubbles which do not readily break out of mud. Best seen by raking surface of mud sample and observing for bubbles at freshly exposed surface.
2. More severe stages:
   a. Strong gas odor at flow line.
   b. Gas pockets cause mud to flow by heads.
   c. Distillate forms emulsion with mud, which reduces effectiveness of chemical treatment.
   d. Volume of mud in pit increased just before blowout, indicating that mud is leaving hole faster than pumps can handle it.

Chemical Treatment

1. At first definite indication of gas put guns on pit and start mixing weighting material to overcome gas pressure. Increase chemical treatment to reduce viscosity and gel rate of mud. Mark level of mud in pit, and observe frequently for any increase or decrease in mud level.
2. In extreme cases, close blowout preventers and put mud discharge on choke. Choking mud discharge should be done only when absolutely necessary, as this slows circulation of mud and thereby concentrates the gas in a smaller volume.
3. Immediate action is the best solution to gas cutting. Any unnecessary delay in increasing mud weight causes recirculation of gas-cut mud and increases the danger of blowout.

Rock-Salt or Salt-Water Flow

"Symptoms"

1. Rapid increase in salt content of mud.
2. First effect is increased gel rate and viscosity. After several hours or perhaps a day, viscosity drops below normal.
3. Water loss increases rapidly.
4. In case of salt-water flow, mud continues to flow after pumps have been shut down.

Chemical Treatment

1. In case of salt-water flow, increase mud weight as rapidly as possible until shutoff is obtained, but **watch closely** for loss of mud to the formation, and stop weight increase if this occurs (even though some flow of water continues) until mud loss is stopped by addition of plastering agents.
2. In extreme cases, pull up in casing to condition mud, as the danger of stuck drill pipe is serious when salt water is encountered.
3. Add **large** quantities of highly collodial clay, preferably hydrated in fresh water before addition to the mud.
4. Copious additions of Quebracho are sometimes helpful in reducing "salt-water gel."
5. In severe cases, substitute organic colloids for clay in mud.

Heaving Shale

A. Bentonitic heaving shale:

"Symptoms"

1. Increase in mud viscosity and gel strength.
2. **Reduction** in water loss and cake thickness.
3. Tight places in hole.

Chemical Treatment

1. Reduce water loss to lowest possible value.
2. Reduce mud pH to 7.2 to 7.6 by use of pyrophosphate.
3. Low pH muds tend to have very low gel strength. Do not reduce pH low enough to prevent suspension of weighting material and cuttings.
4. Keep mud viscosity and gel strength as low as possible to prevent swabbing.

5. Use sodium-silicate mud in very severe cases.

B. Gas-bearing heaving shale:

"Symptoms"

1. Sour-gas odor at share shaker.
2. Little increase in viscosity unless bentonitic shale is also present.
3. Tight places in hole.

Chemical Treatment

1. Reduce water loss of mud.
2. Increase mud weight until difficulty is stopped or until loss of mud to formation begins.

C. Plastic-flow heaving shale:

1. Large slabs of shale circulated out of hole.
2. Shale may flow into hole to a height of a hundred or more feet on removal of drill pipe.
3. Stuck drill pipe or tight places in hole.
4. Usually found on highest part of structure.

Chemical Treatment

Same as for "B."

Cavity, or Highly Porous Formation

"Symptoms"

1. Partial or complete loss of mud returns.

Chemical Treatment

1. If rate of mud loss is low, allow viscosity to increase slightly, but keep gel strength low.
2. In more severe cases, use mechanical plastering agents such as cellophane, mica flakes, etc.
3. If cavity, usually necessary to set pipe before normal drilling operations are resumed.

High-Temperature Decomposition of Phosphates

"Symptoms"

1. Temperature at flow line, 120 deg. F or higher.
2. Viscosity of mud high despite continuous additions of phosphates.

Chemical Treatment

1. Use Quebracho in equal proportion with phosphate.
2. If above not successful, use dicyandiamide. To be added rapidly to a concentration of 0.5 lb. per bbl. of mud, followed by addition of a mixture of dicyandiamide with complex phosphate or Quebracho as required to maintain satisfactory viscosity.
3. Excessive use of this compound sometimes produces objectionable reduction in gel strength of mud.

High Concentration of Colloidal Matter

"Symptoms"

1. Viscosity high, and not improved by chemical treatment.
2. **Low water loss.**
3. Usually high total-solids content.

Chemical Treatment

1. Reduce mud pH to less than 8.0, but not less than 7.2, by use of monosodium phosphate or sodium acid pyrophosphate. Watch gel strength of mud in reducing pH, as it tends to become too low to support weighting material and cuttings.
2. Alternate the use of the various chemicals available for viscosity control.
3. Dilute with water and maintain weight by addition of weighting material, if necessary.

Presented to the Division of Production's Twenty-Third Annual Meeting of American Petroleum Institute November 10, 1942.

Common Chemicals in Use for Viscosity Control

(Compliments of Arthur G. Levy)

The following list of chemicals in use for viscosity control of drilling muds is arranged in order of pH values, varying from a low of 1.5 to a high of 12.6—depending somewhat upon concentration.

Chemical	Formula	Approximate pH
Phosphoric acid	H_3PO_4	1.5
Gallic acid	$C_7H_6O_5$	3.4
Sodium acid pyrophosate	$Na_2H_2P_2O_7$	4.8
Crude tannic acid	$C_{14}H_{10}O_9$	5.0
Chesnut extract	$C_{14}H_{10}O_9$ (approximate)	6.4
Sodium hexametaphosphate	$(NaPO_3)_6$	7.0
Sodium bicarbonate	$NaHCO_3$	8.2
Disodium phosphate	Na_2HPO_4	8.6
Sodium tetraphosphate	$Na_2P_4O_{13}$	8.7
Borax	$Na_2B_4O_7$	9.1
Tetrasodium pyrophosate	$Na_2P_4O_7$	9.9
A mixed soda	$Na_2CO_3.NaHCO_3$	10.1
Soda ash	Na_2CO_3	11.0
Trisodium phosphate	Na_3PO_4	11.3
Sodium metasilicate	Na_2SiO_3	11.6
Caustic soda	NaOH	12.6

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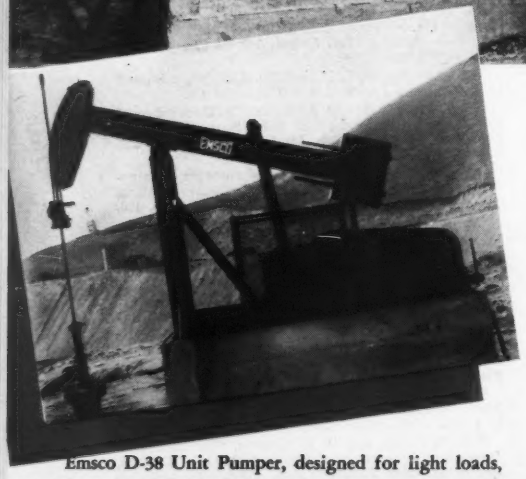

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